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INDUSTRIAL WASTE SURVEY REPORT. GAYLORD CONTAINER CORPORATION, PULP AND PAPER MILL, BOGALUSA, LOUISIANA. OCTOBER 30 TO NOVEMBER 17, 1950. A STUDY OF THE CHARACTERISTICS OF THE INDIVIDUAL AND COMBINED WASTES OF A KRAFT AND SEMI-CHEMICAL PULP AND PAPER MILL

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Environmental Health Center
Cincinnati, Ohio

1950

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Industrial Waste Survey Report

GAYLORD CONTAINER CORPORATION

Pulp and Paper Mill

Bogalusa, Louisiana

October 30 to November 17, 1950

A Study of the Characteristics of the Individual and Combined Wastes of a Kraft and Semi-Chemical Pulp and Paper Mill

By

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ABSTRACT

The wastes of a large integrated kraft and semi-chemical pulp and paper mill were studied over a period of ten sampling days for the purpose of determining the characteristics and volume of total wastes and wastes of each process operation. In this mill about seventy per cent of the pulp is washed in a modern countercurrent system. Diffusers are used for the remainder. Dilution water for knot removal is recirculated to a large extent. Final wash waters are partially reused together with fresh water for pulp dilution purposes in transporting pulp from the initial washing to the knot removal operations. Some recirculation of water is practiced in paper machine operation. Wastes from the three cylinder machines, which machines make about 30% of total paper production, are not passed through any kind of fiber recovery equipment. The four Fourdrinier machines are equipped with cylindrical screen type savealls some of which are of insufficient capacity to handle the wastes.

The pulp mill had a nominal daily capacity, air dry basis, of 650 tons of sulfate pulp and 100 tons of semi-chemical pulp. The sulfate pulp was produced from various southern pine species, and the semi-chemical from oak.

The principal wastes of pulp manufacture at this mill consist of (1) log fluming water used to transport the logs from the unloading area to the mill proper, (2) condensate from degassing the digesters at the beginning of the cook, (3) condensate from release of steam from the digesters at the end of the cook, (4) pulp leaks and spills from handling the black liquor, (5) back-wash of filters used to screen remaining fiber from the black liquor before it is evaporated, (6) condensate from evaporation of the black liquor, (7) pulp wash water which is too dilute for profitable chemical recovery, (8) water and foam lost through the vacuum seal pumps of the counter-current washer operation (9) undissolved material from the chemicals recovered in the furnace smelt, and (10) lime kiln stack gas wash.

The sewerage system and measuring installations existing at the mill were not such that segregation according to the above listed operations was entirely possible. Listed in the following table are the component wastes as designated at the mill, the operations producing these wastes, and average of results obtained.

Waste Designation	Source of Waste or Explanation	Flow		B.O.D. 5-Day 20° C.		Suspended Solids
		mgd	Gallons per Ton of Air Dry Pulp (10% moisture)	ppm	Pounds per Ton of Air Dry Pulp (10% Moisture)	ppm
Log Flume Water	Water used for log fluming. This water was previously used in various operations. Characteristics obtained by difference.	10.3	13,200	3	0.33	51
Black Liquor Weir	Pump leaks, spills, and washups from black liquor handling	0.10	128	596	6.36	92
Digester Room No.2 Waste	Condensate from release of steam from digester at end of cook (Condensed in heat exchanger). Also contains wet room pit water lost through leakage in heat exchanger.	0.635	814	400	2.72	
Turpentine Separater Discharge	Condensate from degassing the digesters at the beginning of cook and during pressure reduction at end of cook.	0.022	28	7750	1.82	
Brown Stock Washer Waste	Water and foam lost through the vacuum seal pumps of the counter-current pulp washer.	0.50	641	987	5.27	
Wet Room Pit Water	Pulp wash water and knot removal dilution water (overflow from collection chamber).	2.92	3740	338	10.5	195
Black Liquor Filter Backwash	Backwash of filter used to screen remaining fiber from black liquor.	0.06	77	2900	1.86	
Black Liquor Evaporator Condensate	Condensate from evaporation of black liquor. This water is contained in barometric condenser water (Condenser water volume not included).	1.23	1580	494	6.49	
Recovery Room Waste	Cooling water from the furnace spouts and condensate overflow from the forced draft air heaters in the recovery furnace.	0.55	705	12	0.07	
Green Liquor Dregs	Undissolved material from dissolving the chemicals recovered in the furnace smelt and wash of lime cake on filters.	0.0085	11	1260	0.12	605,000
Lime Sewer	Lime kiln stack gas wash excess	0.648	830	21	0.14	

These results indicate that wastes from pulp washing, that is wet room pit water and brown stock washer wastes, contain 53 per cent of the total B.O.D. of all component wastes of pulp manufacture. Condensates from digesters and evaporators constitute 37 per cent of the total and the remaining 10 per cent comes from the other wastes associated with chemical recovery. Only negligible quantities of B.O.D. are contained in log fluming water. Pulp washing wastes make up 20 per cent of the volume of all pulp manufacturing wastes. Condensates, not including the cooling or barometric condenser water, account for 11 per cent of the volume. Log fluming water, which is made up of barometric condenser water plus the evaporator condensate, constitutes 60 per cent of the total waste volume.

The entire production of the pulp mill plus about 100 tons of waste paper are utilized in the paper making operations of the plant. Seven paper machines, three cylinder and four Fourdrinier, are utilized. The wastes of five of the machines were measured and sampled individually, and the total wastes of all machines were sampled and volumes determined. The type of product manufactured and quantity, B.O.D., suspended solids and fiber loss of the wastes of these machines are tabulated in a table following. The high flow and concentration of pollutants in machine 4 wastes results from the fact that the semi-chemical pulp, which is used entirely by this machine, receives no washing, beyond that furnished in the diffuser, before it is delivered to the refining system of the machine.

PAPER MACHINE WASTES
AVERAGE FLOW, BOD, FIBER LOSS

Machine Number [1]	Average Daily Production During Survey in Tons [2]	Type of Machine	Product	Flow		B.O.D. 5-Day 20° C.		Suspended Solids ppm	Fiber Loss	
				mgd	Gallons per Ton of Product (6% moisture)	ppm	Pounds per Ton of Product (6% moisture)		Pounds (oven dry) per 1000 gallons Waste	Loss Per Cent of Product
1	125	Cylinder	Fill grades of liner board.	2.10	16,800	127	18	456	3.4	3.1
2	90	Cylinder	Fill grades of liner board and chip board.	2.35	26,100	84	18	192	1.4	2.0
4	126	Four-drinier	Corrugating board (semichemical & pine knot pulp)	3.62	28,700	418	100	609	5.1	7.7
5	72	Four-drinier	Bag and wrap, light-weight.	1.44	20,000	62	10	311	2.4	2.6
6	90	Four-drinier	Bag and wrap, heavy and industrial.	1.94	21,600	55	10	128	1.0	1.1
Total Paper Machine Wastes	843	-	-	19.0	22,600	142	27	361	2.7	3.3

1 - Wastes of machines 3 and 7 were not sampled.

2 - Tons as produced, 6% to 7% moisture.

Averages of results of more important analyses of samples taken from the outfall sewers is tabulated below. Fiber and pulp loss figures for these particular samples were computed from results obtained by the technical staff of the mill.

Waste	Flow		BOD 5-day 20°C.		Suspended Solids ppm	Fiber Loss		Soda Loss Pounds Na_2SO_4 per ton of pulp
	Total mgd	Gallons per ton of product (6% moisture)	ppm	Pounds per ton of product (6% moisture)		Pounds per 1000 gals.	Per Cent of Product (6% Moisture)	
Total pulp & paper mill wastes	30.4	37,200	260	80	1060	1.4	2.7	150

GENERAL INFORMATION

1. Organization of Survey

This investigation was conducted by the Environmental Health Center of the U. S. Public Health Service with the cooperation of the Gaylord Container Corporation. Representatives of the Louisiana Stream Control Commission and the National Council for Stream Improvement of the Pulp and Paper Industry furnished advice and counsel in planning and conducting the survey.

Analytical determinations were carried out in mobile laboratory units and in the laboratory of the mill. Chemists of the Public Health Service performed the analyses and Public Health Service engineers supervised the sampling and flow measurements. The technical staff of the Gaylord container Corporation aided personnel of the survey in becoming familiar with operations of the plant and supplied pertinent operational data. The corporation also furnished utility connections for the mobile units, engineering equipment, and the services of one man for sample collection.

2. Dates

Oct. 30 thru Nov. 3 - Sampling of major wastes of pulp manufacture.

Nov. 13 thru Nov. 17 - Sampling of wastes from paper machines and remaining wastes of pulp manufacture.

3. Personnel

Personnel participating in preliminary meetings at which this in-

vestigation was arranged, in planning conferences, and in conduct of the survey included the following:

GAYLORD CONTAINER CORPORATION
Vertrees Young, Executive Vice President and Resident Manager
Alfred Suter, General Superintendent
W. F. Gillespie, Technical Director
J. J. Goss, Assistant Technical Director
A. R. Haarala, Chemist
A. E. Reed, Chemical Engineer
F. C. Ratliff, Chemical Engineer
J. E. Sapp, Chemical Engineer

LOUISIANA STREAM CONTROL COMMISSION
Frank J. Coogan, Technical Advisor

NATIONAL COUNCIL FOR STREAM IMPROVEMENT
Dr. H. W. Gehm, Technical Advisor
W. A. Moggio, Southern Resident Engineer and Project Leader

U. S. PUBLIC HEALTH SERVICE
L. F. Warrick, Chief, Technical Services Branch. W.P.C.
M. LeBosquet, Jr., Director of Field Activities, E.H.C.
H. H. Black, Chief, Industrial Wastes Section, E.H.C.
M. B. Ettinger, Scientist, E. H. C.
W. W. Walker, Chemist
Carl N. Shadix, Chemist
G. N. McDermott, S.A.Sanitary Engineer
Virgil Minch, J.A.Sanitary Engineer
S. D. Pinkoski, Physical Science Aide

4. Purpose

The objective of this study was the determination of the characteristics and volumes of individual and combined wastes of kraft pulp and paper manufacture and related information concerning the manufacturing processes involved.

5. Location of Plant

The pulp and paper mill of Gaylord Container Corporation occupies a tract of land of about 30 acres located within the city limits of Bogalusa, Louisiana. This city, which has its economy closely allied with the mill operation, is located near the Louisiana-Mississippi border some sixty miles north of New Orleans.

6. Production

The nominal capacity of the pulp mill operation is as follows:

Sulfate pulp - 650 tons (air dry)

Semichemical pulp - 100 tons

In addition as a part of paper mill operations about 100 tons of waste paper is pulped daily

Production on the days during which sampling and analysis of pulp and wastes were carried out was as follows:

Date	Sulfate Pulp Tons (air dry)	Semi Chemical Pulp Tons (air dry)	Total Tons (air dry)
Oct. 29	734	55	789
30	734	65	799
31	734	45	779
Nov. 1	734	25	759
2	734	40	774
Average			780

The paper mill produces daily from 625 to 1000 tons of finished paper, 6-7% moisture. Products include:

Bag, wrapping, and laminated papers

Filled and chip grade boards

Cylinder liner board

Fourdrinier liner board

Corrugating board

Bleached papers - capacity of plant 150 tons daily

A variety of specialties

Average production during the period of sampling and analysis of wastes of the paper machines was 843 tons of finished paper, 6-7% moisture.

By-products are:

Turpentine - unrefined
Tall oil

7. Raw Materials

The average daily intake of raw materials at this plant is as follows:

Pine	1200 cords	(5500 lb. cords, as received basis)
Hardwood	100 cords	(5500 lb. cords, as received basis)
Waste Paper	100 tons	
Limestone	250 tons	
Salt Cake (Na_2SO_4)	60 tons	

Natural Gas	Chlorine
Sodium resinate size	Sulfur
Wax size	Mercurial and phenolic germicides
Alum	Starch
Dyes - basic	Asphalt

Species of wood processed during the survey period were in the following proportions:

Softwood:		Hardwood:	
Loblolly pine	75%	Red Oak	90%
Slash pine	13%	White Oak	10%
Longleaf pine	7%		
Shortleaf pine	3%		
Spruce	2%		

8. Operation

The pulp mill operates continuously at practically a constant rate, variations in pulp usage being evened out by storage of pulp. On rare occasions semichemical operations are suspended. Short time shutdowns

for maintenance occur biannually.

Paper machines are operated continuously except for monthly and biannual maintenance shutdowns. The range of products manufactured results in appreciable variation in pulp usage from day to day.

The bleach plant, during recent months, has operated only a small part of the time. During the war years it was operated extensively. No bleaching was done during the time the survey was being conducted.

9. Water Supply

Water is obtained from two sources. Ground water is obtained from five deep wells, ranging in depth from 160 to 800 feet, which are pumped at a rate of about 1100 g.p.m. each. The remaining water is pumped from Bogue Lusa, a small stream flowing by the plant, to a large settling pond and is screened before use. Cooling water is pumped from the pond and returned to the pond via cooling sprays.

10. Sewerage

All process wastes from this plant are discharged through two main sewers to Bogue Lusa at a point some 2.4 miles above its junction with Pearl River. No treatment is provided for any of the plant wastes.

Separate sanitary sewers exist throughout the mill. Sanitary sewage is discharged without treatment to the main sewers of the plant below all weirs, flumes, and sampling devices.

PULP MANUFACTURING PROCESS

The process of pulp manufacture consists essentially of separating the cellulose fibers from most of the lignin, hemi-celluloses, and other compounds of wood. The general operation of the process employed at Gaylord Container Corporation mill is outlined below. This plant operates both kraft and semi-chemical processes, the latter being of minor proportions. A flow diagram of the processes is shown on Figure 1.

11. Kraft Process

Log-Handling and Chipping

Wood is obtained from an area extending up to 220 miles from the mill and shipped to the mill by rail or truck. Logs supplied the mill are 5" to 14" in diameter and are cut in 63 inch lengths. The softwood logs are dumped in a sunken concrete channel, called a flume, in which water is flowing. This flume, a recent innovation at this plant, is considered the most economical method by which logs may be transported from the railroad yards to the mill proper. Though at present the flume is only a few hundred feet long, it is planned to eventually extend it along one half mile or more of railroad track.

Water flowing in the flume transports the logs to a haul-up. The haul-up is an inclined trough at the bottom of which is located a chain conveyor. Projecting flights on the chain catch the logs and elevate them to a tumbling barrel type barker. Bark rubs from the logs as they tumble against one another in a revolving drum. The bark passes through small openings in the drum and falls to a conveyor below. This bark plus bark recovered from screening the flume water is conveyed by belt conveyors

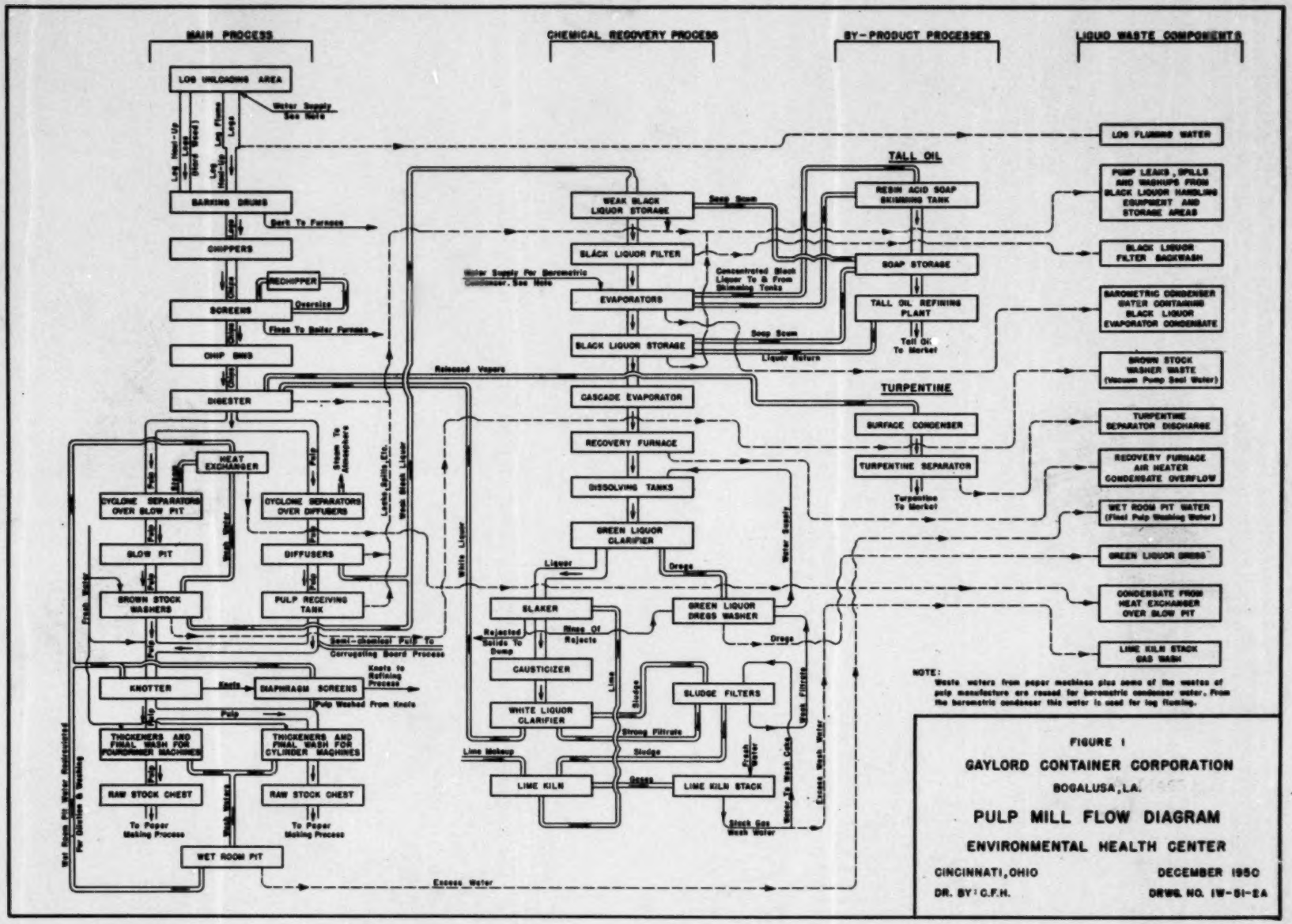

FIGURE 1

GAYLORD CONTAINER CORPORATION

BOGALUSA, LA.

PULP MILL FLOW DIAGRAM

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12a

to the furnaces. Debarked logs work their way out the discharge end of the drum.

A second log haul-up elevates the debarked logs to a chute which feeds the chipper. Gravity forces hold the logs against the revolving disk of the chipper. Knives projecting through the disk reduce the logs to chips 5/8" in length. Maximum thickness of chips is about 1/8" and their width varies from a sliver to seldom more than 1/2 inch. The chips are then passed over shaker type flat screens which separate the large chips and also the fine particles from the acceptable sizes. Fines are conveyed to furnaces and the larger rejections to a hammer mill crusher which reduces the size of the chips. The reprocessed chips are returned to the flat screens. Screen chips are carried to bins located over the digesters.

Digestion

The Gaylord mill operates 24 stationary direct-heated digesters. The digesters are cylindrical upright steel tanks with conical bottoms and tops. Chips are dumped to the digesters from the bins above. The required amount of white liquor is added. White liquor is an aqueous solution the active ingredients of which are sodium hydrate and sodium sulphide. It also contains sodium carbonate, sodium sulphate, sodium thiosulphate, sodium sulphite and minor amounts of other compounds. Black liquor is added to bring the liquor to the necessary volume to cover the chips. Black liquor is the name applied to liquors recovered from the digesters following completion of the cook. Steam is admitted in the bottom cone of the digester where it contributes not only heat and pressure to the process but also agitates the mass of chips and chemicals.

After the pressure has reached about 20 pounds per square inch a valve is cracked which releases the non-condensable gases from the top of the digester. Air must be removed to prevent oxidation of the cellulose and the other non-condensable gases must be removed in order to obtain the correct temperature-pressure relationship in the digester. The gases are bled off until pressure is up to 110 pounds, a period of about 45 minutes. Gases released are passed through cyclone separators to capture any carry over and thence to the turpentine recovery system. Material separated in the cyclone is returned to the black liquor tanks.

The digester is closed and the cook continued for 2 hours at 110 pounds per square inch pressure. The chemical reactions taking place are rather indefinite but involve hydrolysis of the lignin to alcohol and acids. Material in the digester is, after cooking, a loose mass of hair like cellulose fibers each about 3 millimeters in length which are immersed in a solution of spent chemicals, condensed steam, and dissolved constituents of the wood. Each oven dry pound of wood chips yields about 0.43 pound of fiber, the remaining wood being dissolved.

At the end of the cooking period, the gases are released through the turpentine recovery system until the pressure is reduced to 90 psi. Turpentine separation is accomplished by condensing portions of digester gases by means of surface condensers. The condensate is a mixture of condensed volatile liquids of the wood and water. Water is separated from other condensed materials by gravity in a vertical-flow skimming tank. The supernatant is marketed as crude turpentine. The sulfate

process usually yields from 1 to 3 gallons of crude oils per ton of pulp. This oil is approximately 50 to 60 per cent turpentine and 10 to 20 per cent pine oil. The remainder is chiefly dimethyl sulphide and methyl mercaptan, with some methanol, acetone, petones, etc.

Pulp Washing and Screening

The next step in the process is the separation of the fiber in the material in the digesters from the liquid. The fiber is referred to as pulp and the liquor as black liquor. Washing is necessary to rinse liquor from the pulp. Since the liquor is evaporated for recovery of chemicals the amount of wash water must be kept at a minimum consistent with maximum recovery of chemicals and well-washed pulp.

The Gaylord mill has two types of equipment for accomplishing this operation. Over 70 per cent of the pulp is blown (transported through pipes by the steam pressure in the digesters) to a cyclone separator which is situated above a receiving tank (blow pit). Material separated in this cyclone falls to the blow pit. Vapors pass through a heat exchanger in which a portion is condensed. Water heated in this exchanger is a portion of that previously used in the pump screening and final wash operations which are described in a subsequent paragraph. This water is referred to at the mill as wet room pit water. That portion heated in this exchanger is reused in initial pulp washing.

From the blow pit, pulp and liquor are pumped to a continuous filter. The filter is a closely woven wire cloth which is attached to the outside of a revolving drum. The drum is partially submerged in a vat containing

the mixture to be filtered. The liquor drains from the vat through the screen into the drum. It leaves the drum through a hollow axial bearing. A mat of pulp is formed on the screen as the liquid drains through. The mat clings to the screen and is lifted from the liquor as the cylinder rotates. Sprays of water are directed on the pulp mat and are pulled through it to the interior of the drum by a pump induced vacuum in the drain line. The interior of the cylindrical screen and its drain lines are so constructed that the water sprays on one side are caught and withdrawn separate from the spray water and vat liquid passing through the other half. Water withdrawn on the second portion of the filter enters a tank from which water for the spray wash on the first half of the screen is withdrawn. Thus counter current washing is achieved. A sharp edged steel plate (doctor blade) scrapes the mat of pulp from the screen. Water is added to dilute the pulp to a consistency suitable for pumping and the pulp suspension is pumped to the vat of a second rotary screen. Two additional washes are provided on this second filter in a manner similar to that described. Water is applied on one half of the screen then withdrawn and used in sprays on the second half, then on to a spray on the other filter, and finally being used on the last half of that filter. Thus four stages counter-current washing is provided. The water used on these filters in the wash just preceding the pulp leaving the washing system is partly wet room pit water and partly fresh water. It would be advantageous to use wet room pit water for the full amount of this wash water, however lack of sufficient pressure in the wet room pit water system necessitates using some fresh water. As the pulp mat is scraped and

flushed from the second filter it is diluted with wet room pit water and pumped to the next operation, knot removal. The liquid now diluted with wash water flows to the chemical recovery system.

Those digesters not discharged to the blow pit are blown to a large cyclone located on a factory building roof. Vapors escape to the atmosphere while liquids and pulp separated in the cyclone fall to diffusers. A diffuser is a cylindrical upright steel tank with a screened false bottom. After being charged with the digester cook, water is admitted at the top of the diffuser. The water, being lighter than the liquor, remains a separate layer above it and as it passes through the fiber mass forces the liquor ahead and out of the diffuser. The liquor flows to the chemical recovery system. When the liquor-water line has reached the bottom of the diffuser the contents are dumped to a receiving tank. Wet room pit water is used to flush adhering pulp from the diffuser. The pulp suspension is pumped from the receiving tank to screens for removal of the knots.

From the standpoint of chemical recovery it has been stated that pulp can be profitably washed to the point of about 1 per cent solids concentration in the wash water. The four-stage counter-current washing at the Gaylord mill is carried to about 0.3 per cent solids because the evaporator capacity to handle the wash is available. These washers are stated to wash to 50 pounds of residual salt cake per ton of air dry pulp with 2.8 pounds of water added to the liquor per pound of air dry pulp.

Some knots and chips do not disintegrate in the digesters. They must be removed from high grade pulp. Gaylord mill employs cylindrical screens with 1/2 inch holes followed by conical screens with 1/8 inch holes. In the

conical screen the pulp suspension enters at the axis and is thrown against the screen by revolving blades. Knots and chips not passing through the holes are discharged at the end of the cone. In order to accomplish the screening with a minimum use of power and equipment, dilution of the pulp with a great deal of water is practiced. The amount of water in pulp is indicated by the term consistency which term means the per cent fiber (dry solids basis). The pulp coming from the diffuser and washer receiving tanks is of about 3% consistency and it leaves the screens at about 1/2%. These figures correspond to an addition of 20 gallons of water per pound of air dry pulp. Water used for this dilution is largely recirculated, although it is diluted to considerable extent by fresh water showers on the thickeners as described in a subsequent section.

Considerable fiber remains with the chips rejected from the screens. This fiber is recovered by washing it from the knots by means of diaphragm screens. Showers of wet room pit water on the screens move the material along the screen and rinse the chips. Finally the chips leave the screen and are transported to a receiving tank. The separated fiber and rinse water joins the pump stock supply of paperboard making operations.

From the knot removing screens, the pulp flows to rotary cylindrical screen filters which are similar to that described for counter-current pulp washing. These filters, usually referred to as thickeners, remove water added in the knot screening operation. Fresh water is sprayed on the pulp mat as it passes along the upper portion of the screen's circuit. This water flows through the mat by gravity, no vacuum being provided, and gives the pulp its final wash. The pulp mat is scraped from the filters by a doctor

blade and is diluted and flushed with fresh water to a receiving tank which supplies the paper manufacturing operations.

Some of the filters are provided with press rolls which are located on top of the cylindrical screen. Water is pressed from the pulp mat as it passes between the press roll and the cylindrical screen. Pulp can be pressed to about 19% consistency by this means. Pulp going to storage is handled at this consistency.

The dilution water and spray wash water removed on the rotary filters flows to a collecting tank known as the wet room pit. Wet room pit water is reused in the counter-current washers, for dilution of washed stock following counter-current washing, for diffuser flushing, and for knot screening.

The knots are diluted to a consistency suitable for pumping with wet room pit water and recycle water from the semichemical operations. The diluted knots are pumped to flat screens equipped with traveling flights. These screens are called drainaters. The knots are drained on the drainaters and fall to a set of hammer mills and attrition mills which reduce the knots to a pulp. The water which flows from the knots on the drainaters mixes with water from semichemical operations and is partially reused as shown on Figure 6. The knot pulp joins the semichemical pulp and is used with it for paper making.

Chemical Recovery

The feasibility of the kraft process, economically speaking, is dependent on recovery of the sodium from the black liquor and its return to the form of chemical compound used in the cook. Black liquor contains 95 to 98 per cent of the sodium charged to the digester. Most of the sodium is present as sodium carbonate, sodium organic compounds with properties similar to carbonate, sodium salts of resinous and other organic acids, and as sodium hydrate and sulfide. There are also small amounts of sodium sulfate, chloride, silica, and minute amounts of other impurities. Organic matter dissolved from

wood makes up 55 to 70 per cent of the total solids in black liquor.

The concentration of black liquor depends on the strength of the chemical charge to the digester, the water added as steam in cooking, and the efficiency of the washing operation. At the Gaylord mill black liquor from the kraft process is obtained at 14 to 15 per cent total solids and amounts to about 1900 gallons per ton of air-dry pulp. It contains about 2800 pounds of solids per ton of pulp.

The first step in recovery is concentration of black liquor to the density required for self-combustion in the recovery furnaces. Weak black liquor is concentrated to about 51 per cent solids by two sextuple and one quintuple effect evaporators. Water evaporated amounts to about 1580 gallons per ton of pulp. Weak black liquor contains pulp fiber which has passed the filters. In order to prevent clogging troubles in the evaporation and subsequent operations the weak black liquor is screened through a fine meshed rotary screen. Fiber on the screen is removed by a doctor blade and a steam back-wash. A water shower flushes this material to waste. Concentrated black liquor from the evaporators is further dewatered as it passes over cascade evaporators through which furnace gases are forced. Soda losses of the mill are made up by addition of salt cake, Na_2SO_4, to the liquor as it enters the cascade evaporators. Losses at this mill ordinarily run from 160 to 180 pounds of salt cake per ton of pulp. The liquor is sprayed into the recovery furnace. In the furnace residual water evaporates, then organic compounds are broken up and the more volatile organic compounds burned. A mixture of carbon and inorganic chemicals results and under suitable air supply regulation the carbon is burned out with reduction of a certain amount of sodium sulfate

to sodium sulfide. The black liquor materials form a molten mass in the furnace bottom called smelt. The smelt is a mixture of sodium carbonate and sodium sulfide, plus minor amounts of sodium sulfite, sodium sulfate, etc. The smelt flows from the furnace to a dissolving tank where it dissolves to a great extent, resulting in a solution called green liquor. The material contains insoluble matter, i.e., silicates, carbon, etc., which must be removed. At the Gaylord mill this is accomplished by a tray type circular clarifier. Sludge from the green liquor clarifier is discharged to a second clarifier in which soda traces are rinsed from the sludge by countercurrent flow of water. This water is then used to dissolve the smelt. Thus its soda content is returned to the system. The washed sludge, called green liquor dregs, are drained to the sewer.

The sodium carbonate contained in the green liquor must be converted to sodium hydroxide in order to obtain the necessary chemical mixture for the cook. At the Gaylord mill, this is accomplished by adding the green liquor to powdered lime in a rotary double pass slaker. Material which does not dissolve in the slaker is removed and flushed to a sump from which it is pumped to the green liquor dregs washer. The limed green liquor mixture is stored in causticizing tanks for several hours and then the precipitate of calcium carbonate is settled out in tray type clarifiers. The supernatant, called white liquor, goes to storage for ultimate use in the digesters. Sludge from the clarifiers is washed to low sodium content by a three stage counter-current rotary filter washing system. The wash water is used in the green liquor dregs washer. The sludge, which is essentially calcium carbonate, is calcined in kilns and continuously reused. A fresh

water shower spray in the stacks of the kiln is used to remove dust from the kiln gases. Part of this water is used for washing sludge from the white liquor clarifiers. That portion not so used is dumped to waste.

Associated with the chemical recovery process is the recovery of fatty and resin acids from crude soaps present in black liquor. These soaps are more or less insoluble in black liquor and tend to separate and float out. This action is accelerated by concentration. At the mill the major portion of the soaps separated are skimmed from the liquor at the point of about 28% solids in the evaporation process. The liquor is pumped to open tanks on the factory roof for the skimming operation. Some soaps are recovered from foam on the black liquor storage tanks. The soaps are refined by special process which plant officials stated produced only one waste, a negligible amount of sludge. Liquid separated from the soaps is returned to the black liquor tanks.

12. Semi-chemical Process

The process employed in the semichemical operation is quite similar to the kraft process. The process makes possible the use of hardwoods for pulp. In the following discussion, process descriptions similar to those of kraft are not repeated; only differences between the two processes are pointed out.

Log Handling and Chipping

Logs for the semichemical process are handled by a chain haul-up direct from the car unloading stations to the barking drums. No fluming is done. Barking and chipping is carried out in the same manner as that described for the kraft process.

Digestion

Cooking of semichemical pulp is similar to kraft cook except that only about 40 per cent as much white liquor is used per ton of pulp. The necessary volume is made up with black liquor.

Pulp Washing and Screening

Semichemical digester loads are blown via a cyclone separator to a separate group of 8 diffusers. Water used in the diffusers for washing pulp is recirculated to a certain extent. It is mixed with waste water from one paper machine and from pine knot drainings so that recirculation is not complete. Knots are not screened from semichemical pulp. From the diffusers it is dumped to a receiving tank, from which it is passed to a flat screen equipped with traveling flights, called a drainater. The consistency of the pulp is increased from 3 to 10 per cent on the drainaters. The water separated on the drainaters, which amounts to about 2.8 gallons per pound of pulp, mixes with water from other operations. A part of the mixture is used for diffuser wash water; the remainder is wasted. The intricate arrangement of this recirculation system is described in section 16 and shown in figure 6.

The pulp passes from the drainaters through a primary set of attrition mills which are in effect mechanical grinders. The semichemical and pine knot pulp is mixed and passed through a second set of attrition mills to a receiving tank. This mixed pulp constitutes the raw pulp for corrugating board manufacture.

Chemical Recovery

Black liquor from semichemical cook is mixed with black liquor

from the kraft process and the mixture handled as has been described.

13. Waste Paper Pulping Process

Waste paper at the Gaylord mill is used for cylinder board paper, therefore refinements of processing such as careful sorting and deinking are unnecessary. The waste paper stock is fed to two beaters. In the beater the paper is repulped, that is converted to a watery mass of fibers. Rags and metal clips and other extraneous material are separated from the waste paper pulp by special devices. The pulp is dewatered on a rotary cylindrical filter and passed to the stock refining system of the paper-making process.

The pulping of waste paper actually consumes water, since the pulp stock produced is of a higher water content than the waste paper. Advantage is taken of this feature at this mill; the water system is a closed circuit. Waste waters from paper machine number 1 are used as make-up water. Reference is made to figure 2 which shows a flow diagram of the process.

PAPER MANUFACTURING PROCESS

The manufacture of paper consists essentially of matting the fibers of pulp together. This is accomplished on machines of two types: (1) cylinder and (2) Fourdrinier. These two types of machines are described briefly in subsequent paragraphs. Gaylord Container Corporation operates three cylinder machines and four Fourdrinier machines. The specific operation of each machine is discussed in subsequent paragraphs. Uses of fresh water, re-use of water, points of waste and such shown on the diagrams are those employed at the time of the survey. Numerous alternative supplies

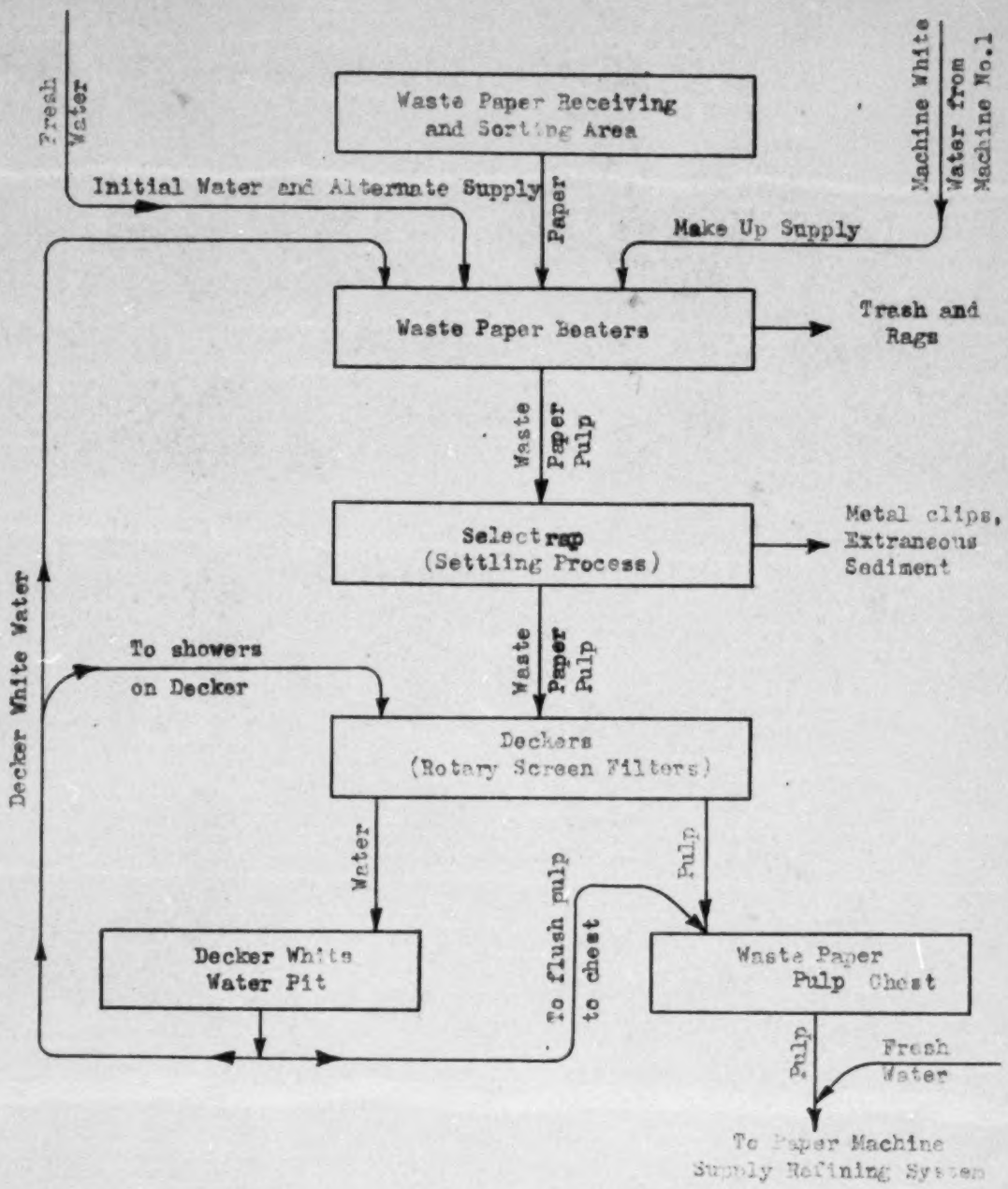


Figure 2

WASTE PAPER PULPING SYSTEM

Gaylord Container Corp.
Pulp and Paper Mill
Bogalusa, La.
Environmental Health Center
Cincinnati, Ohio Dec. 1950
Drwg. No. IW-51-4

and facilities for re-use of waters are in existence. The flow diagrams show paths of flow only; the quantities involved in each operation could not be measured within the limits of time and equipment available.

14. Pulp Refining

Pulp as delivered from the pulp washing operations contains bundles of fibers which must be broken up and the fibers need be given a final mechanical treatment before the paper sheet is formed. Machines known as beaters, Jordans, and refiners are used for this purpose. The fibers are separated by these machines and distributed throughout the material in such a manner as to make the stock consistent and homogeneous. In addition, the fibers are brushed to a greater flexibility and given better matting properties by the operation. Beaters, Jordans, and refiners may be used in series or in any combination.

A beater is a large oval tank containing a central dividing partition which in effect converts the tank to a continuous channel. In this channel a cylindricel drum is placed. Around the periphery of the drum and more or less parallel to its axis are mounted many steel blades which fit closely to similar blades in a concave section of the channel flow. The cylinder rotates rapidly and pulls the stock through the blades, breaking up the fiber bundles and combing the fibers in the process. The pulp is circulated around the beater channel until it is in satisfactory condition, then the beater is dumped and a new batch added. Some beaters are equipped with drawoffs so that stock is admitted and withdrawn continuously.

A Jordan is a machine consisting of a conical shell, inside of which

is a close-fitting plug. Many projecting bar type blades, running lengthwise of the shell, are fitted to its inside surface. Rotating inside of the shell is a conical plug, the outside surface of which is fitted with projecting blades. The two sets of blades are adjusted to clear by a very minute distance. The plug is rotated rapidly. The pulp stock is forced into the small end of the conical shell, passed through the small space between the plug and the shell, and leaves at the large end. The action of the whirling, closely spaced blades gives the required properties to the pulp.

A refiner consists of movable and stationary discs which are both provided with many projecting blades. The discs are so adjusted that the blades clear by minute distances. The movable disc rotates rapidly and the pulp passes between the discs.

Material referred to as "size" is added to paper stock to give the paper a less porous and less absorbent surface. Resin size is used at the Gaylord mill. Alum is used in conjunection with resin in order to precipitate the resin on the fibers. These materials are added during the pulp refining process. Coloring materials at the mill are added to the paper stock in the beaters.

15. Cylinder Machines

The leading features of a cylinder machine are the cylinder vat and cylinder mold. Reference is made to figure 3 which is a simplified drawing of a cylinder machine. The mold is a wire mesh covered cylindrical frame which is partially submerged in a vat containing dilute paper stock. Refined paper stock is diluted to low consistencies and fed to the vats continuously.

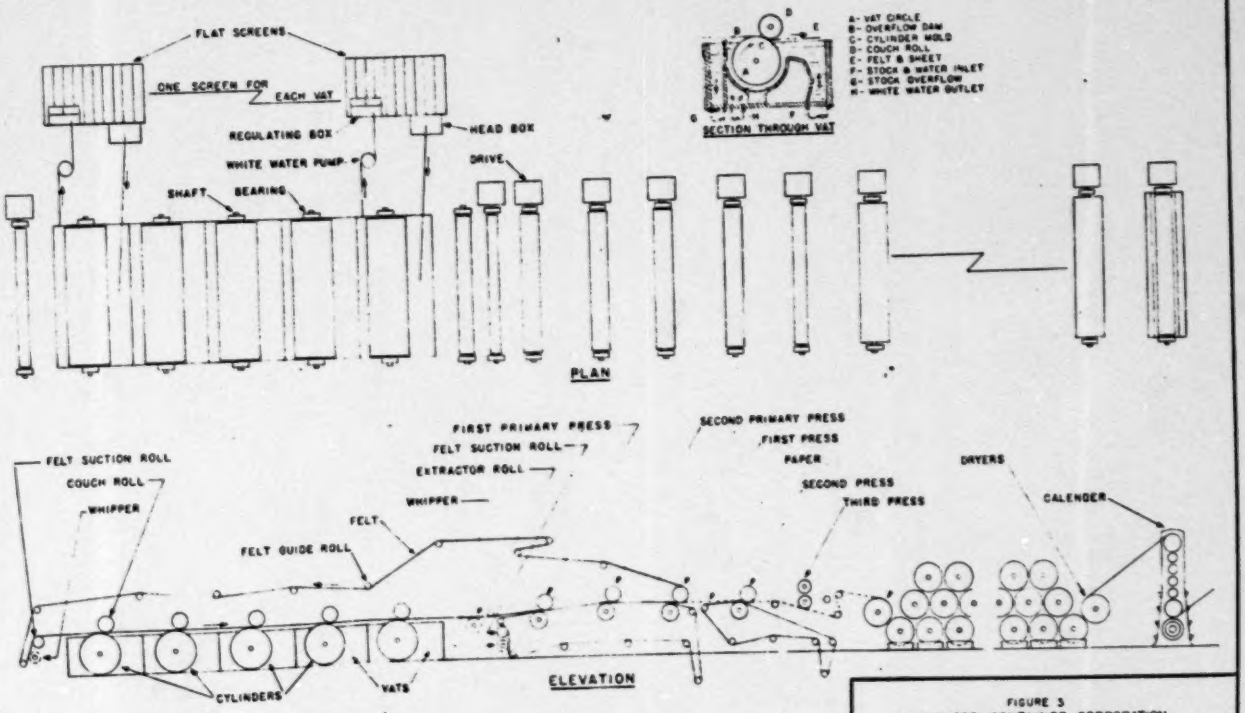


FIGURE 3
GAYLORD CONTAINER CORPORATION
BOGALUSA, LA.

SCHEMATIC DIAGRAM
CYLINDER MACHINE

ENVIRONMENTAL HEALTH CENTER
CINCINNATI, OHIO DEC 1950

DR BY RNE DRWG NO IW-51-2

As the stock water strains through the revolving cylindrical screen, a mat of fiber forms on the wire mesh. A moving endless felt belt contacts the cylinder over a small portion at the top. As the cylinder rotates, the mat of fiber passes from the cylinder to the felt because of its greater adherence to felt. The felt belt moves along at a speed equal to that of the periphery of the mold and carries with it the pulp mat. The belt returns over rollers following the passing of the pulp sheet on to dewatering devices. A paper machine usually contains several molds and vats, each adding a layer of fiber to the sheet. The sheet of fiber is dewatered and pressed smooth by extractor rolls, press rolls, suction rolls, and steam-heated driers and thus formed to a sheet of paper. An extractor roll has a wire mesh face through which water in the mat is squeezed. Press rolls are solid-faced rolls between which two felts with the paper sheet between are pressed. A suction roll has a vacuum applied to a section of the interior of the roll. This suction pulls water from the felt and paper mat as they pass over the roll. The felt is dewatered on its return circuit by whippers and felt suction rolls. Felt whippers are multiple-bladed rotors which revolve rapidly. The blades strike the felt and beat the dirt and water from it. Driers are steel cylinders, the inside of which is heated with steam.

The wire of the cylinder mold is flushed clean by a spray of water which is applied in the section of the cylinder between the point on top at which the felt loses contact with the cylinder and the liquid level in the vat. Water from these showers enters the vat and dilutes the stock or passes through the cylinder.

The growth of slime-forming bacteria and fungi in the pulp stock and

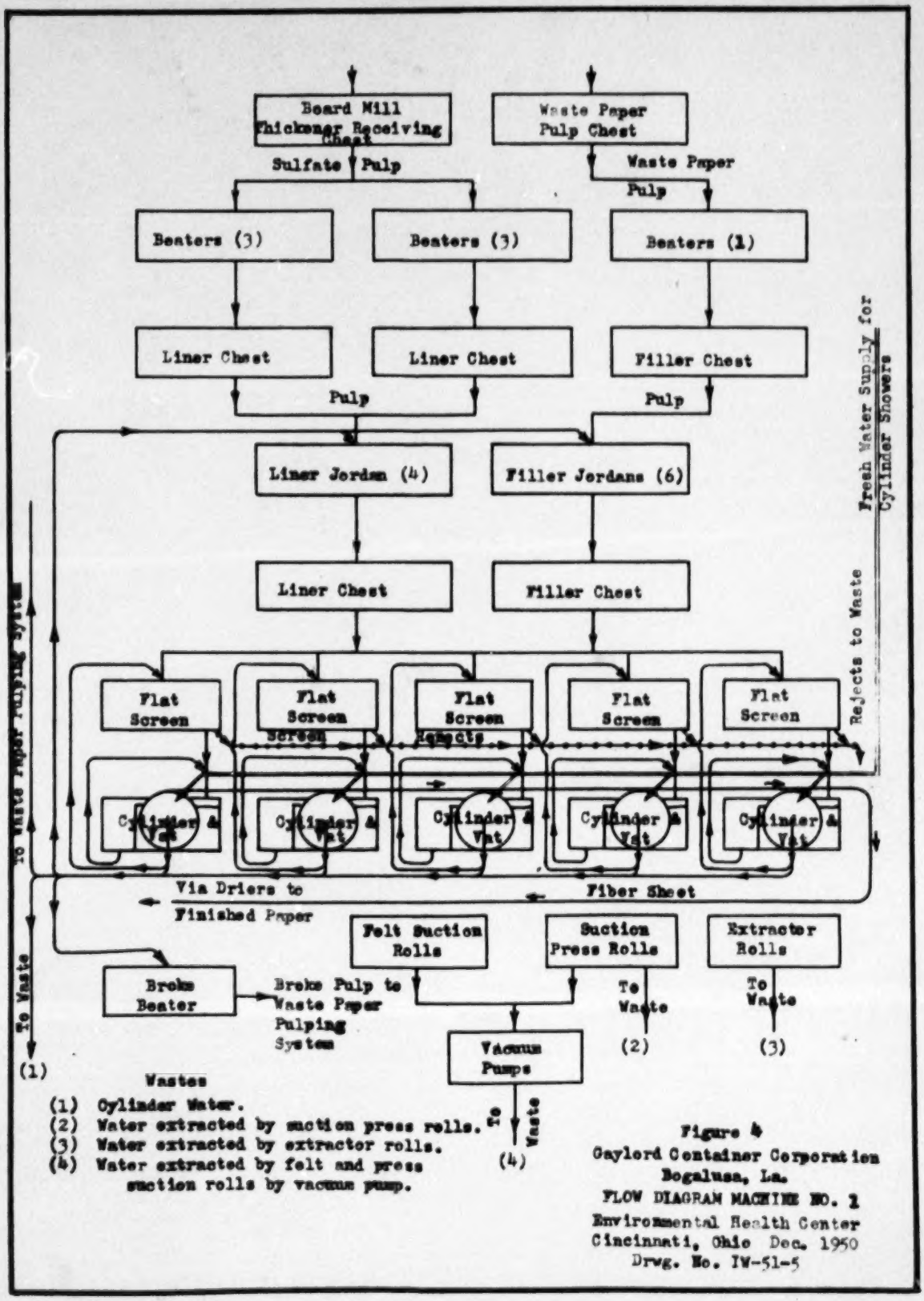
recirculated waters is controlled by intermittent application of chlorine compounds.

Machine No. 1

This is a cylinder machine of five vats and molds having a rated capacity of 125 tons per day. The machine is used to make fill grades of liner board, a small amount of test chipboard, and a little kraft. Machines 1 and 2 use all of the waste paper pulp. The white water and broke system of machine 1 is integrated with waste paper pulping, figure 4. Broke is the term applied to imperfect and rejected sheets, trim, etc. Pulp is refined by beaters and Jordans, as shown in the diagram, figure 4. Some kraft pulp is kept separate from waste paper pulp and is used for the outside layer of the paper sheet, the liner. The other layers contain the waste paper pulp. The stock used to form them is called filler stock. After passing through the Jordans the pulp goes to a headbox where it is diluted to a very thin consistency. This diluted stock is screened through coarse screens for the purpose of removing large particles. From the screen the stock enters the cylinder vats. The sheet of fibers forms on the cylinder molds and transfers to the felt as previously described. Water draining through the cylinder is re-used in part for the stock dilution. The fiber mat is dewatered as it passes over extractor rolls, suction press rolls and driers. The finished sheet is wound on steel spools.

Machine No. 2

This is a cylinder machine of six vats and molds having a rated capacity of 90 tons per day. The machine is used to make fill grades of liner board, some test chipboard and all of the nontest chipboard (100%



Wastes

(1) Cylinder Water.
(2) Water extracted by suction press rolls.
(3) Water extracted by extractor rolls.
(4) Water extracted by felt and press suction rolls by vacuum pump.

Figure 4
Gaylord Container Corporation
Bogalusa, La.
FLOW DIAGRAM MACHINE NO. 1
Environmental Health Center
Cincinnati, Ohio Dec. 1950
Drwg. No. IW-51-5

waste paper). Operation, as far as flow of materials and circulation of water is concerned, is similar to that of machine 1. The screening of pulp going to the cylinder vats is carried out by coarse rotary cylindrical screens known as selectifiers instead of by flat screens. Fresh water enters the system via the cylinder showers, all of which operate on fresh water.

Machine No. 3

This cylinder machine has four vats and molds having a rated capacity of 38 tons per day. A superior grade of solid kraft test liner is produced. Broke from this machine goes to the broke beaters of machines 1 and 2. Fresh water is used in the cylinder showers and for diluting stock in the Jordan headboxes. Some of the water draining through the cylinder molds from this machine is used to dilute stock as it leaves the board mill thickeners. This is the only reuse of water in this machine's system.

16. Fourdrinier Machines

In a Fourdrinier machine, the pulp, in a very dilute condition is distributed in an even flow across a wire screen, Figure 5. The wire screen of 50 or 60 mesh is in the form of an endless belt and travels at a high speed in a horizontal direction for a considerable distance from the point at which the pulp flows on it. The wire is supported, kept taut, and driven by rolls at the ends, and along its path. A mat of fibers collects on the wire as the water drains through. The mat of fiber is the rudimentary form of a paper sheet. Additional water is removed by means of a series of suction boxes which operate in narrow strips across the width of the wire. The paper sheet is transferred from the wire to a felt belt which carries it over press

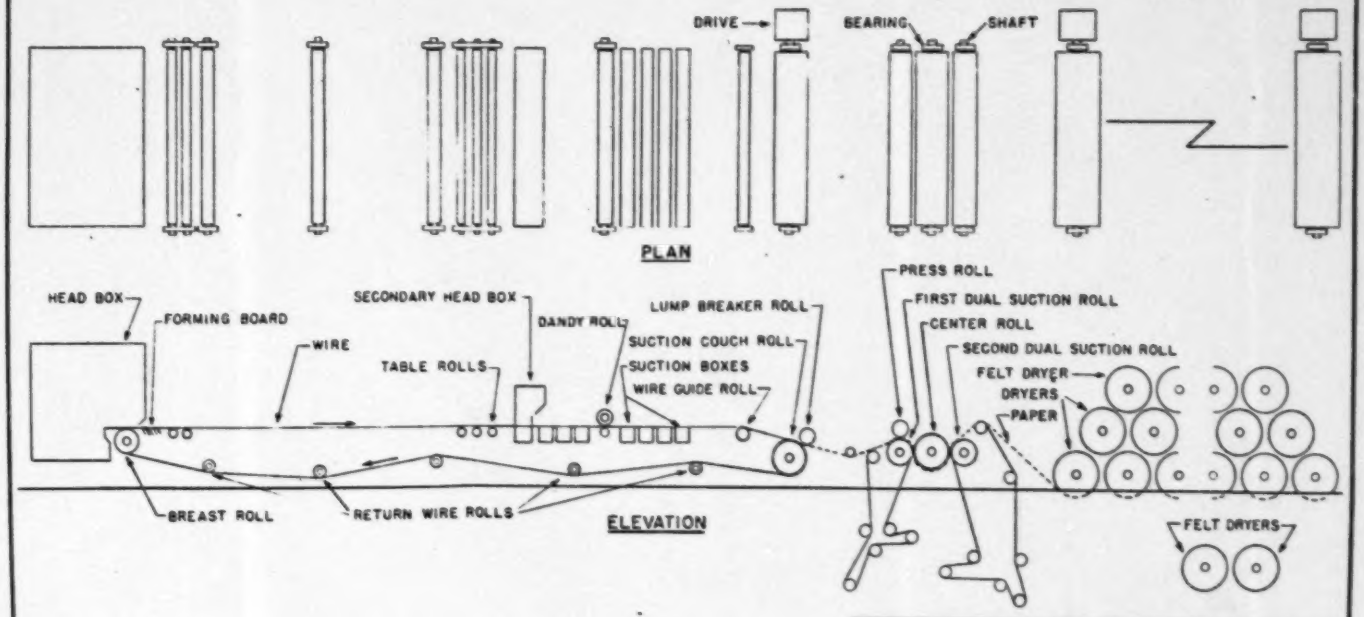


FIGURE 5

GAYLORD CONTAINER CORPORATION
BOGALUSA, LA.

SCHEMATIC DIAGRAM
FOURDRINIER MACHINE

ENVIRONMENTAL HEALTH CENTER
CINCINNATI, OHIO DEC. 1950

DR BY RWE

DRWG. NO. 1W-51-1

and suction rolls by means of which more water is removed. The paper sheet passes around a long series of steam-heated cylinders which evaporate much of the remaining water. It then passes through a stack of polished steel rollers which give it a smooth finish and finally is wound on spools.

Water which drains from the pulp through the wire is caught on pans before it reaches the wire returning underneath. It is referred to as "pan water." This water is carried to a shallow tank called the wire pit, which extends over most of the area beneath the wire. At the end near where the paper leaves the wire, is a deeper tank called the couch pit. At times when the machine is starting up or is not forming perfect paper, or when the mat sticks to the wire, the unfinished paper sheet is diverted to the couch pit. The edges of the fiber mat are trimmed by means of high pressure water squirts. This water and paper trim flows to the couch pit. The couch pit is provided with an agitator to break up the pulp mats and trim, and keep the pulp in suspension. The suction boxes act as their own water traps, being provided with a drain which ends in a seal tank on a floor level below.

The wire on its return path is back-washed with large volumes of water in spray showers. The first of these showers is located just after the point where the wire starts its return circuit. This spray serves to knock any pulp which sticks to the screen into the couch pit. At times of putting the machine in operation, and during difficulties in operation, the entire sheet of paper may be flushed to the couch pit by this spray. Additional spray washes are, in cases, provided along the return wire, and usually one operates just as the wire passes around the end roll. These latter sprays drain to the wire pit.

Water from the wire pit and the couch pit is re-used to a certain extent for dilution of the paper stock going on to the wire, and for some of the wire showers. Most of the wire showers at this mill were operated on fresh water.

Couch and wire pit water are, in part, filtered on rotary screen filters to recover pulp fibers which they contain. These filters are like those used in pulp washing operations. In this use, they are often referred to as "savealls." Since the amount of pulp contained in these waters is quite limited, it is the usual practice to add some fresh pulp to the filter vat in order to form a mat of fibers on the filter. By forming the initial mat of fibers without delay, the loss of fibers through the screen is reduced. The capacity of savealls provided at this plant was insufficient in cases to filter all water from the paper machine.

Paper that is trimmed from the finished sheet, or that which may be taken off the driers or press rolls when the machine is not in complete operation, is termed "broke." Each machine is provided with a beater in which the broke is repulped. Couch or wire pit water is used to dilute broke in the beater. The repulped stock is pumped to the saveall and thus returned to the system.

Machine No. 4

This is a Fourdrinier machine which has a rated capacity of 140 tons per day. The machine is used almost entirely to make corrugating board from semichemical hardwood pulp and from pulped pine knots. Semichemical pulp makes up, in general, about 60% of the total. For short and infrequent periods, the machine is used for a liner run.

The washing operation of semichemical pulp is limited to that received

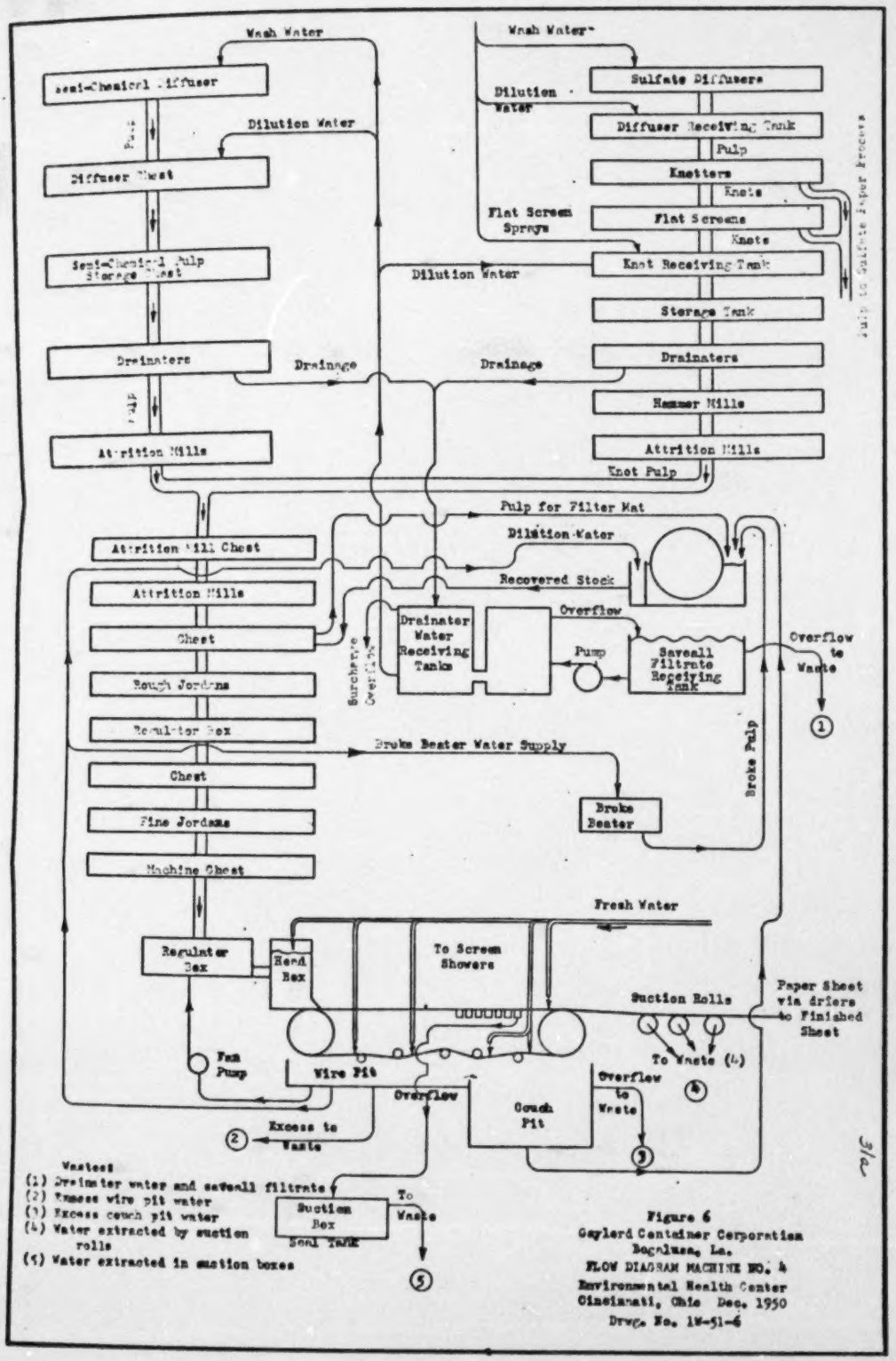


Figure 6
Gaylord Container Corporation
Bogalusa, La.
FLOW DIAGRAM MACHINE NO. 4
Environmental Health Center
Cincinnati, Ohio Dec. 1950
Drwg. No. 1W-51-6

in the diffuser. As shown on the flow diagram, Figure 6, water removed on the drainater is mixed with paper machine wastes and re-used in the diffuser for washing and dilution of pulp. Though this operation touches on being a pulp washing operation, the wastes are considered in this report as associated with paper making. The stock is refined in attrition mills and Jordans, from which it passes to the machine chest. From the machine chest, the pulp goes to consistency regulators where it is diluted with wire pit water to proper consistency. Next it enters the machine headbox and flows out onto the wire. A shower of fresh water on the surface of the stock in the headbox controls foaming. The paper sheet forms on the wire as the water drains away. The mat is transferred to a felt belt and is dewatered as it passes over suction rolls and driers. The wire is back-washed with fresh water which enters the wire and couch pits. Wire pit water is used for dilution of stock and in the broke heater. Excess wire pit water, which is of considerable quantity, goes to the sewer. The saveall filter is of such limited capacity that little couch pit water is passed to it. A good deal of the couch pit water overflows to the sewer.

Machine No. 5

This is a Fourdrinier machine which has a rated capacity of 85 tons per day. The machine is used for making light weight bags and wrapping paper. Stock for the machine is refined in beaters and Jordans, then passed via the machine chest and headbox to the wire, Figure 7. Wire and couch pit water in this machine is all reused or passed through the saveall filter, or to the thickener of the stock supply. Wire and couch pit water entering the thickener for machines 5 and 6, flows

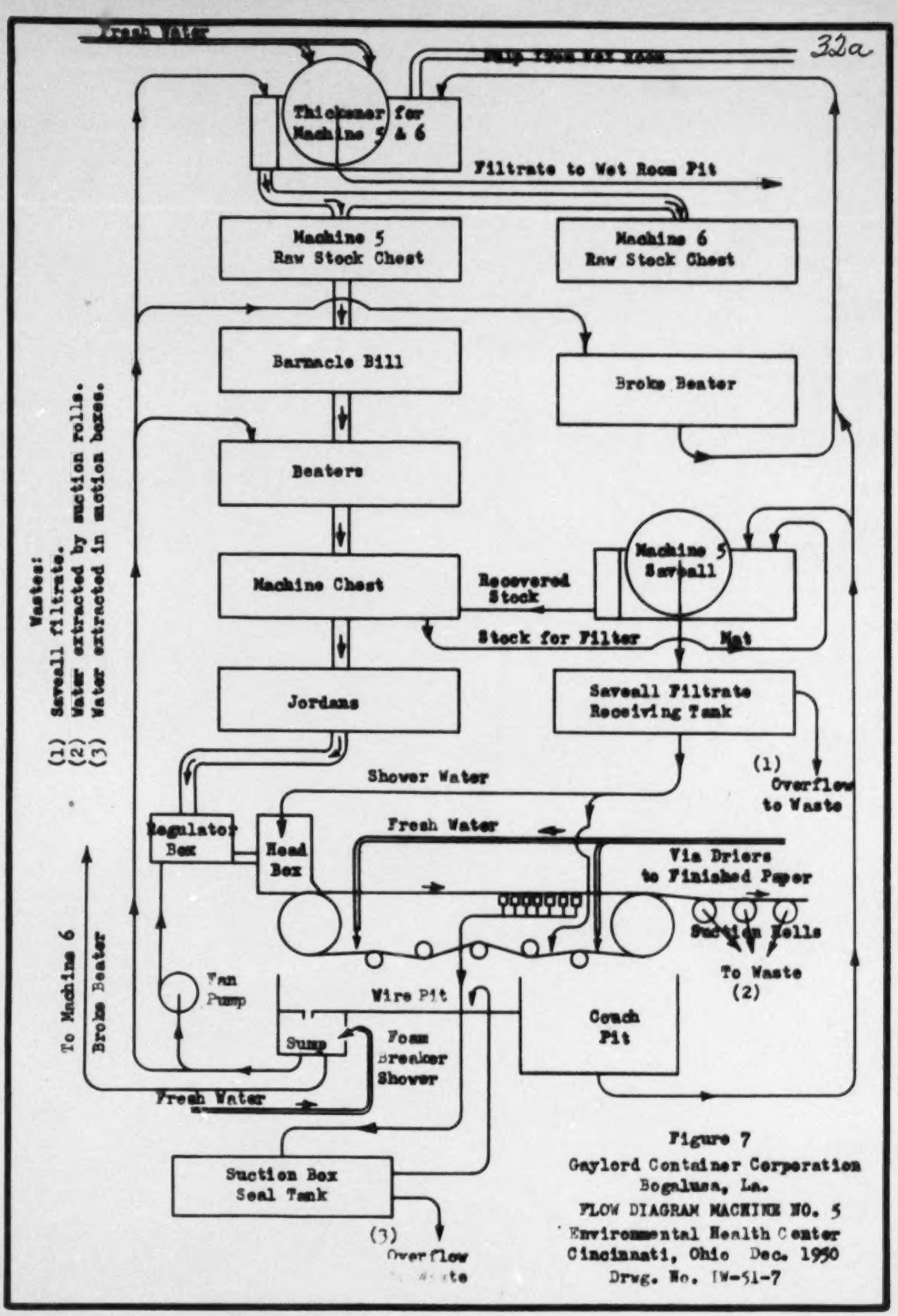


Figure 7
Gaylord Container Corporation
Bogalusa, La.
FLOW DIAGRAM MACHINE NO. 5
Environmental Health Center
Cincinnati, Ohio Dec. 1950
Drwg. No. IW-51-7

through the filter to the wet room pit. Wire pit water of machine 5 is used for dilution in the broke beater of machine 6. Couch pit water which cannot be handled on the saveall flows to the thickener. One of the wire showers and the foam-control shower in the headbox operate on filtrate from the saveall. This machine has the most extensive system of waste re-use and recovery of any of the machines.

Interconnections of machines 5 and 6 in the thickener and broke systems, are necessarily closed during times when papers different in color are being made. Couch pit water, which normally would flow to thickener, is wasted when operating on colored stock. When wire pit water of machine 5 is colored, fresh water is used in machine 6 broke beater.

Machine No. 6

This Fourdrinier machine has a rated capacity of 95 tons per day. In the main, the machine is used for making heavy weight bag and wrap, and some industrial wrap. Stock for the machine is refined in beaters and Jordans, then flows through the regulator box to the machine headbox, Figure 8. Couch pit water, which cannot be handled on the saveall, flows to the thickener of machine 5 and 6. Filtrate from the saveall is used for the machine head box showers.

Machine No. 7

This high-speed Fourdrinier machine is a modern Beloit Iron Works unit which, as a recent addition, 1941, of the mill, increased total capacity a substantial per cent. The machine has a maximum rated speed of 1500 feet per minute, and takes a 216 inch wire, trimming to 196 inches. The machine

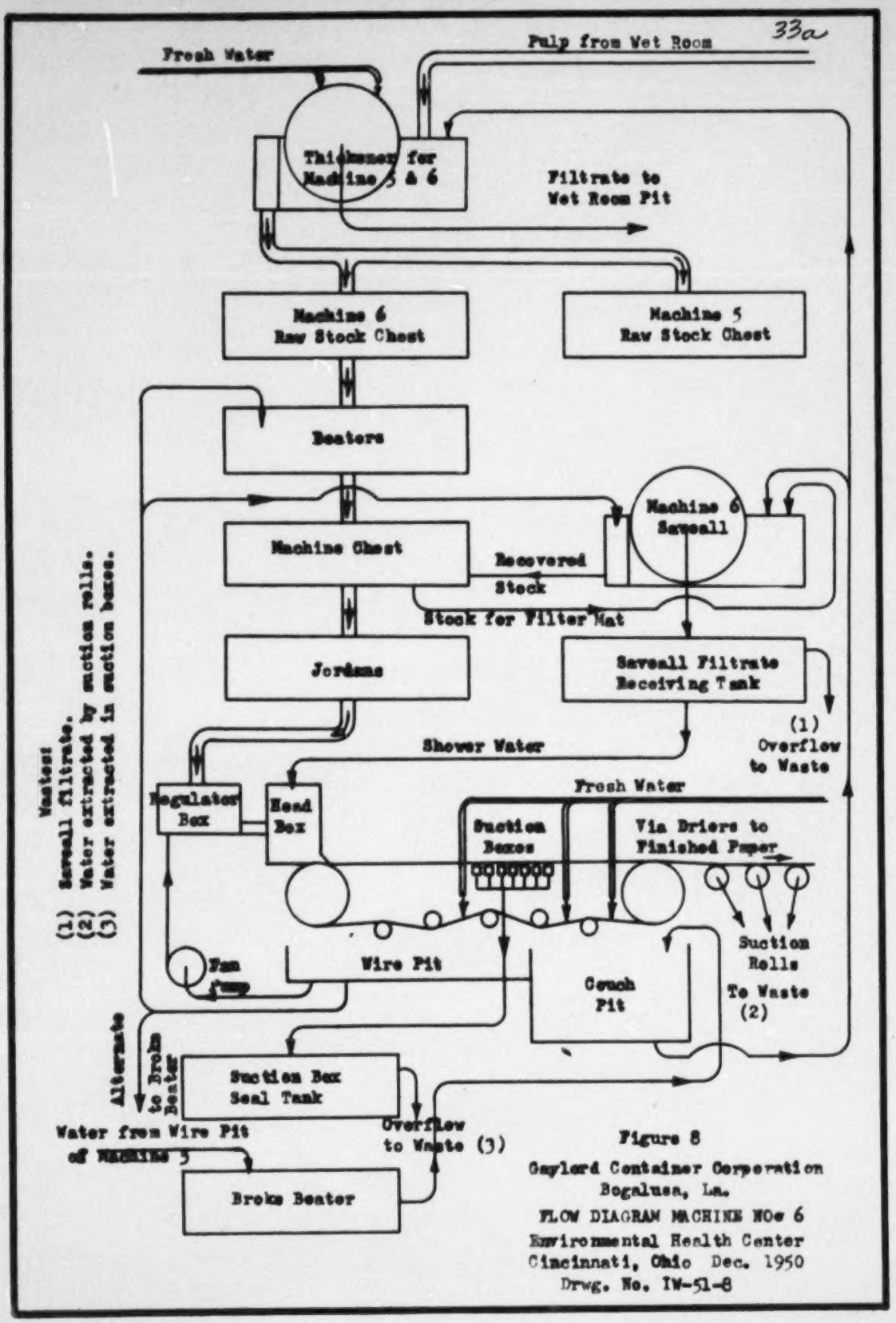


Figure 8

Gaylord Container Corporation
Bogalusa, La.

FLOW DIAGRAM MACHINE NOe 6

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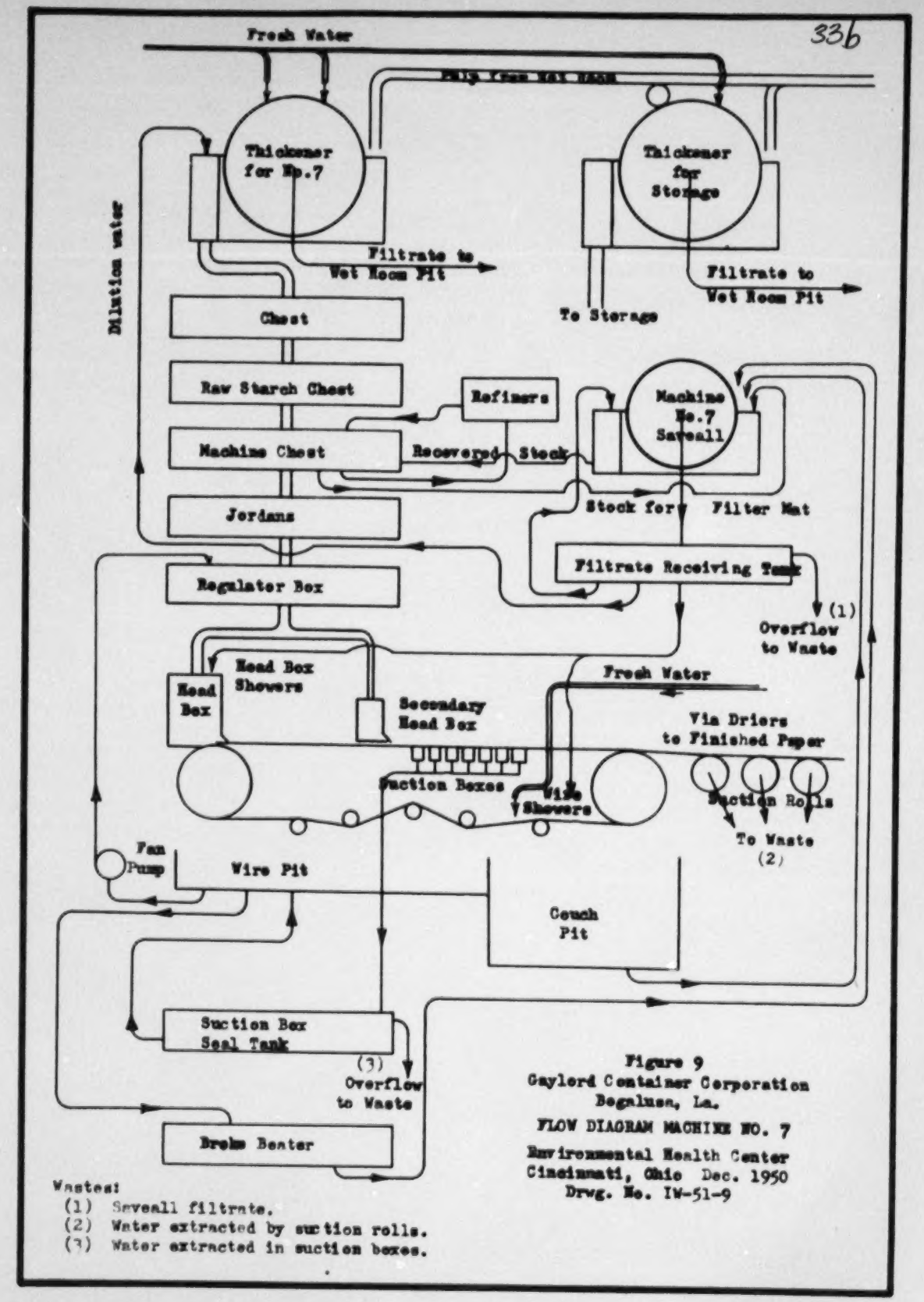

Figure 9
Gaylord Container Corporation
Bogalusa, La.
FLOW DIAGRAM MACHINE NO. 7
Environmental Health Center
Cincinnati, Ohio Dec. 1950
Drwg. No. IW-51-9

Wastes:
(1) Saveall filtrate.
(2) Water extracted by suction rolls.
(3) Water extracted in suction boxes.

is operated approximately two thirds of the time on liner board, which it produces at a maximum rate of about 425 tons per day. The remaining one-third of the time, the machine is used to make a bag paper, and produces roughly about 185 tons per day. The fan pump is rated at 23,000 gallons per minute at 30 foot head.

Stock is refined in Jordans and refiners and passes to the headboxes as shown in the flow diagram, Figure 9. A secondary headbox is provided when making liner board, in order to insure a smooth surface and even thickness. A saveall, 8' in diameter x 14' long, is used for all couch pit water. A great deal of the saveall filtrate goes to waste. However, it is used on one wire shower and for the headbox foam control showers.

FRESH WATER USES

Principal fresh water uses are as follows:

Pulp Mill:

1. Final wash water sprays on thickeners before pulp passes to the paper mill.
2. Dilution of pulp for its transport from the counter current washers to the knotters.
3. Gas washing sprays in lime kiln stack.

Paper Mill:

4. Cylinder and felt showers.
5. Some Fourdrinier machine wire showers and head box showers.

Cooling Water:

6. Cooling water used in furnace walls and indirect condensers is drawn from the water supply pond and returned to it via sprays.

WASTE REDUCTION MEASURES

Of particular significance in recapitulation of process operations and

measures which reduce liquid waste quantities or concentrations are the following:

1. Counter-current washing of about 70 per cent of pulp production.
2. Recirculation of final wash water and knot removal dilution water for counter-current washer supply, diffuser flushing, dilution of pulp for transporting, and dilution for knot removal.
3. Reuse of a mixture of paper machine and pulp mill wastes for barometric condenser supply.
4. Reuse of barometric condenser effluent for log fluming.
5. Reuse of lime kiln stack gas wash water for filter cake and dregs washing.
6. Reuse of water in machines of the paper mill for diluting broke in the broke beaters and in waste paper pulping operations.
7. Recirculation of waters in the semi-chemical system for transporting pulp and in the head box shower.
8. Reuse of paper machine waste waters for some wire showers.
9. Operation of cylindrical screen type of savealls for fiber recovery from portions of the waste waters of four Fourdrinier machines.

SURVEY PROCEDURES

17. Flow Measurements

Measuring devices and recording instruments for establishing pulp and soda losses, existed at 16 locations. These installations measured wastes from various areas and operations of the plant, plus combined flow in the two outfalls. Figure 10 shows wastes handled by each measuring device. Weir crest conditions, velocity of approach conditions, dimensions, and the accuracy of recording devices were checked and corrections applied.

One waste designated "brown stock washer waste," was a frothy mixture which was full of air bubbles throughout its depth. This waste was measured by Parshall flume. The hydraulic head of frothy material was balanced by a slight flow of fresh water through the connecting line from the float well

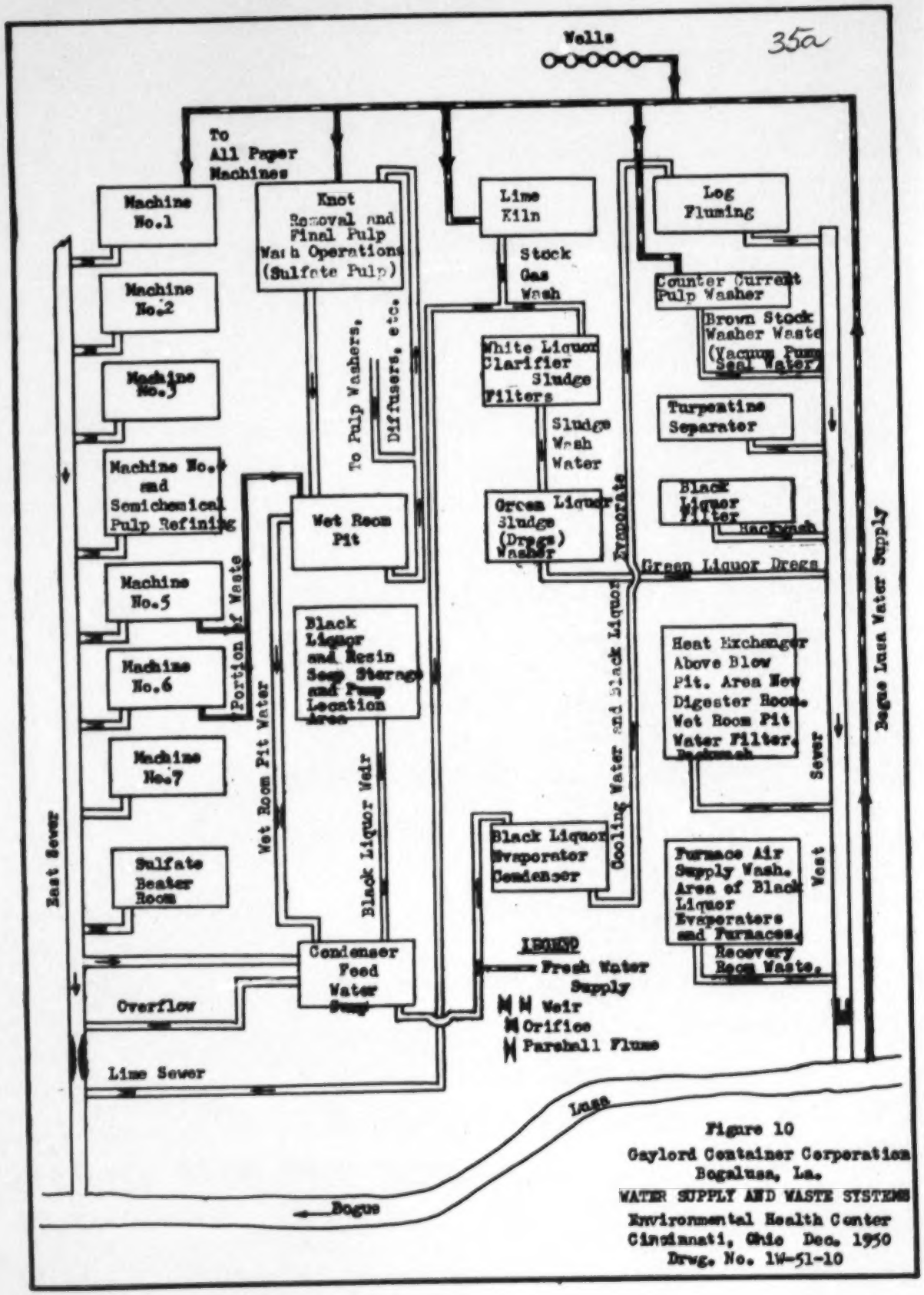

Figure 10
Gaylord Container Corporation
Bogalusa, La.
WATER SUPPLY AND WASTE SYSTEMS
Environmental Health Center
Cincinnati, Ohio Dec. 1950
Drwg. No. 1W-51-10

to the flume. Discharge corresponding to the head of fresh water was assumed.

The Parshall flume measuring wastes from Digester Room No. 2 was found to have become partially blocked after the initial inspection. Prior measurements were disregarded, and average discharge figures, accumulated at a later date, were applied for the sampling period.

Turpentine separator discharge, black liquor filter backwash, and green liquor dregs were measured by timing the filling of containers of known volume. Green liquor dregs discharge was especially difficult to measure. Standard operating procedure at the plant was to open the sludge line of the green liquor clarifier for a period of about 10 minutes each hour. The operator judged by the sludge thickness when to shut off the discharge. This sludge was very thick, high variations and plugging of the discharge line frequently occurred. No method of maintaining a steady flow or a definite sludge level in the clarifier was developed. Figures for the volume of this waste can be considered an estimate only.

The quantity of condensate from black liquor evaporation was estimated from general factory data on the per cent of solids in the liquor before and after passing through the evaporators and on general knowledge of the amount of solids involved.

Condenser cooling water was measured by an orifice in the supply line. The accuracy of the gage recording the head loss was checked. However, it was not practicable to check the condition and size of the orifice.

The weir installations of paper machines Nos. 1 and 2 had been partially by-passed since their installation. The volume of by-passed wastes were measured by current meter in the trough drains. Such measurements were considered accurate to $\pm$ 20%.

The wastes from paper machine No. 4, which are a combination of wastes of pulp washing, and paper making operations, were discharged mainly over a weir as shown on Figure 6. The remaining wastes of the paper machine were discharged at four places. A few months previous to this survey, these wastes had been estimated under more favorable conditions by plant personnel. Average figures obtained in the earlier survey were accepted as satisfactory for estimates of the flows during this survey.

Saveall receiving tank overflow of paper machine No. 6 was measured by considering the overflow opening as a broad crested weir. The formula $Q = 2.8\ L\ H^{3/2}$ was applied. This measurement could be $\pm$ 20% in error.

The quantity of fresh water supplied to each machine was obtained from charts. The type, accuracy, or condition of these measuring devices was not checked at the time of the survey. Plant personnel considered them accurate.

The volume of total paper machine wastes was computed as follows:

Total Paper Machine Wastes = East Sewer + Black Liquor Evaporator Condenser Feed Water - Black Liquor Weir - Wet Room Pit Overflow

18. Sample Collection

Each of the existing measuring devices was equipped with some form of automatic sampler. Chain and bucket types, solenoid-operated valves, and sampling scoops were used. The scoops were designed to sample in proportion to flow, other sampling was done at a constant rate. Fluctuations in flow were not considered sufficient to necessitate compositing according to flow. The samples of automatic samplers were composited over a 12 hour period beginning at 5 PM. In cases where automatic sampling devices did not exist

or were not operating satisfactorily, samples were composited from equal volumes of samples collected by hand at hourly intervals. Hand sampling was carried out over one work shift, 10 PM to 6 AM. Samples were brought to the lab at 8 AM and analyzed the same day. Samples were not iced during the collecting period.

Samples for sulfide determinations were composited in separate bottles to which zinc acetate had been added. The zinc precipitated the sulfides, thereby preventing their volatilization or oxidation.

EXPLANATION OF ANALYSIS

19. Biochemical Oxygen Demand (BOD)

The biochemical oxygen demand of sewage or industrial waste is the amount of oxygen required during stabilization of the organic matter by aerobic bacterial action. Since this is a phenomenon into which both time and temperature enter, a standard set of conditions (5 days, 20° C) is universally used for the test. For domestic sewage and some industrial wastes, approximately 68 per cent of the oxygen requirement of the carbonaceous material present is normally satisfied during the standard test. For industrial wastes with certain characteristics different from domestic sewage, this per cent satisfied during the test may differ considerably.

The BOD test is indicative of deoxygenation which will occur in natural waters receiving the waste. Oxygen deficiencies result in distress to fish and depletions result in noxious odor production.

20. Oxygen Consumed from Dichromate

The oxygen consumed test is a measure of the chemical oxidant required to oxidize the organic matter present in a sample under particular standardized conditions. It is expressed as parts per million oxygen. The test is of value in estimating the strength of certain industrial wastes, and in conjunction with the determination of the BOD. It can be used where it would be advantageous to obtain results indicative of BOD strengths in less time than the BOD test requires.

21. Solids

Solids analyses include those for total solids, suspended solids, and the volatile constituents of each. Total Solids consist of all the solids present in a liquid, the term includes both suspended solids and dissolved solids. Suspended Solids are in suspension or float on the surface of water, sewage, or other liquid, and are removed by laboratory filtering. Dissolved Solids are found by subtracting suspended solids from total. Volatile Solids are those that are lost upon ignition of total solids (giving total volatile solids) or suspended solids (giving suspended volatile solids). Suspended solids cause water to be turbid and unsightly. Fine materials, such as pulp fibers in suspension, are sometimes mentioned as possibly causing distress to fish through catching on fish gills. Suspended solids may settle on the bed of the receiving body of water, with formation of sludge banks.

22. Color

Color is determined by comparison with solutions of known concentrations of potassium chloroplatinate. It is expressed on parts per million basis. Color due solely to substances in solution was determined, as the suspended matter was removed by centrifuging before the color determination. Color is objectionable in domestic and certain industrial water supplies. It is difficult to remove. In streams, color is objectionable on aesthetic grounds and may adversely effect aquatic life through reduction of light transmission.

23. pH

The symbol "pH" denotes the logarithm of the reciprocal of the hydrogen ion concentration. It is a measure of acidity or basicity but is not directly proportional to the amount of acid or base present. The pH is significant for its influence on biological decomposition, and on chemical treatment processes. Extreme ranges of pH in streams may affect aquatic life and increase costs of treatment of water.

24. Alkalinity

Alkalinity of a water or waste is usually caused by the presence of carbonates, bicarbonates, hydroxides, and less frequently by borates, silicates, and phosphates. Alkalinity is determined by neutralization of these compounds with acid to certain equivalence points as given by indicator solutions. Phenolphthalein, or its equivalent, is used for one of these points and methyl orange, or its equivalent, for the other. Alkalinity is expressed as calcium carbonate, parts per million basis. The discharge of a waste of high alkalinity into a watercourse may be of concern when such water is used as a source of

domestic, industrial, or irrigation water.

25. Sulfides

Total sulfides, which includes all dissolved sulfides and also acid-soluble metallic sulfides present as suspended matter were determined. Hydrogen sulfide which was likely to have been one form of sulfide present is readily oxidized by any oxygen which may be in the water and thus exerts an immediate oxygen demand. It has been reported that low concentrations are lethal for fish. Hydrogen sulfide escapes rapidly to the atmosphere from water surfaces. It is a colorless gas which, in low concentrations, has an offensive odor described as that of rotten eggs. The characteristic odor of the gas is detectable in concentrations as low as 0.025 ppm, is distinct at 0.3 ppm, and is intensely offensive at 3 to 5 ppm. Hydrogen sulfide gas reacts with the pigments of lead base paints and darkens them. It is considered a factor in the disintegration of concrete. Mercaptans have also been found in these wastes and are included in the determination. Methyl mercaptan has been reported as being toxic to fish in a concentration as low as 0.5 ppm. Mercaptans are highly volatile, and have an extremely offensive odor even in extraordinary minute concentrations.

RESULTS

Average results obtained during the survey are presented in tables 1, 2, and 3. Individual results are presented in the appendix.

The sewer system and existing measuring devices dictated the pattern of segregating component parts of total wastes. Reuse of waters in several different operations complicates component segregation. Reuse of water is illustrated in the schematic diagram of the water supply and waste system of the factory, Figure 10. A mixture of wet room pit water overflow, black liquor weir waste, and paper machine wastes are reused; first as cooling water in the barometric condenser of the black liquor evaporator and secondly, after picking up the black liquor evaporator condensate, are reused for log fluming. A small amount of wastes from machines 5 and 6 enter the wet room pit. The volume and pollution load so transferred from the paper making to pulp washing wastes is not thought great enough to make seriously in error the attributing of all wet room pit overflow to pulp washing operations. Within the limitations discussed, it was possible to segregate the wastes into those from pulp manufacture and those from paper manufacture.

26. Pulp Manufacturing Wastes

Log Flume Water Discharge

The use of water already containing a great amount of organic pollutants necessitated determining the pollution contributed in log fluming by the difference in pollutional characteristics of water entering and leaving the flume. Water entering the flume consists in part of black liquor evaporator condensate. This condensate may have contained volatile organic matter which would vaporize during agitation in the flume. The results showed that virtually

TABLE 1
AVERAGE OF DETERMINATIONS
WASTES OF PULP MANUFACTURE

WASTE	FLOW mgd	BOD			TOTAL SOLIDS			SUSPENDED SOLIDS			pH	Sulfide	Color
		5 day ppm	lbs/ day	% of total wastes	Total ppm	Volatile ppm	Fixed ppm	Total ppm	Volatile ppm	Fixed ppm	Range	ppm	ppm
Log Fluming Water (by difference)	10.3	3	257	1.1	125	98	27	51	39	13	7.5-8.4	-10	-40
Black Liquor Weir	0.10	596	496	2.1	2307	1376	933	92	91	1	10.2 10.6	1.8	1900
Digester Room #2 Waste	0.635	400	2120	9.1	525	334	191	-	-	-	9.4-9.8	3.9	-
Turpentine Separator Discharge	0.022	7750	1420	6.1	132	86	46	-	-	-	9.3-9.4	39	-
Brown Stock Washer Waste	0.50	987	4110	17.6	4295	2551	1744	-	-	-	9.7 10.6	<0.1	-
Wet Room Pit Water	2.92	338	8220	35.2	1605	1024	581	195	188	7	9.7 10.5	0.1	-
Black Liquor Filter Backwash	0.06	2900	1450	6.2	8096	4826	3270	-	-	-	10.5-10.9	6.0	17,000
Black Liquor Evaporator Condensate	1.23	494	5050	24.6	270	166	-	-	-	-	-	123	-
Recovery Room Waste	0.55	12	55	0.2	505	191	314	-	-	-	9.1-9.6	<0.1	-
Green Liquor Dregs	0.0085	1263	89	0.4	632190	14,960	617230	604640	14,240	559843	>12.2	925	-
Lime Kiln Stack & Gas Wash	0.648	21	113	0.5	2636	-	-	-	-	-	-	5.8	-
TOTAL			23,380										

no B.O.D. was being added to the water used in log fluming. Perhaps the true results are masked by volatile organic matter losses.

The color of water entering the flume was so high that moderate additions would probably not be revealed. The average results indicate no color additions.

Considerable bark breaks from the logs and enters the flume water. Coarser particles are screened from the flume discharge. Even with this screening, considerable increase in solids occurs in the flume water.

Wastes Associated with Digestion

Black Liquor Weir

This waste originates in the area of black liquor and resin soap storage tanks and pumps and from a portion of the diffuser area. The diffuser receiving tanks have recessed floor drains around their bases which receive tank leaks, and washes, and spills from the working floor. Black liquor and soap storage tanks and the pumps are placed on raised bases around which is an open trough drainage system. The soap tank has an overflow which, in emergencies due to plant operational difficulties, has been known to carry considerable resin soap and black liquor to waste. Hose washes are used to flush the materials through the drainage system. No single source of appreciable proportion is evident in this drainage system, even though the system carries an appreciable pollution load. This waste averaged 0.1 mgd in volume and 596 ppm B.O.D.

Digester Room No. 2 Waste

One component of this waste is condensate from the heat exchanger above the blow pit. During the survey, the heat exchanger had a leak between

the vapor and water sides. This leak was to be repaired at the next factory shutdown. The water being heated, wet room pit water, was mixing with the condensate in unknown proportions. Once daily the vapor sides of these heat exchangers are flushed with a large flow of water which goes to the sewer.

Wet room pit water is screened through a fine mesh rotary filter in order to remove pulp which might clog the counter-current washer sprays. Material removed is flushed to this waste. Spills, leakages of black liquor pumps, and bearing cooling water are also in this waste. The quantity of the waste during the survey averaged 0.635 mgd, and its B.O.D. averaged 400 ppm.

Turpentine Separator Discharge

Condensed vapors released from the digesters through the turpentine recovery system constitute this waste. The B.O.D. averaged 7750 ppm, which is several times the strength of any other of the waste components. The volume was only 22,000 gallons per day, however. Of special significance is the fact that total solids averaged but 132 ppm. Obviously, the material which produced the B.O.D. was volatilized in the evaporation process of the solids determination.

Wastes Associated with Pulp Washing and Screening

Brown Stock Washer Waste

This waste originates with the vacuum pumps of the counter current washing system. These vacuum pumps are operated with the plunger sealed by the fresh water. Considerable foaming of the black liquor occurs. This foam enters the vacuum pumps and is discharged with the seal water. This escape of foam to the seal water, and water sprays used to control the foam and flush it to the sewers make up brown stock washer waste. The waste has a high B.O.D., 987 ppm average, and amounts to 0.5 mgd. This represents almost 18 per cent of the B.O.D. load of all the pulp wastes and nearly 10 per cent of the

total pulp and paper wastes.

Wet Room Pit Water

This waste consists of pulp wash water which originates in the final pulp washing operation. It is too dilute for profitable chemical recovery, averaging only 1605 ppm total solids. The waste has a B.O.D. averaging 338 ppm and a flow of 2.75 mgd. Its B.O.D. pollutional load constitutes about one third of that of all pulp wastes and over 17 per cent of all pulp and paper wastes.

Wastes Associated with Chemical Recovery

Black Liquor Filter Backwash

Black liquor is filtered by small 30 to 40 mesh rotary screens in order to remove any pulp which might accumulate in the tubes of the evaporator. Steam jets are used to backwash these screens. Though fiber removed by the screens appears to amount to very little, considerable foam and liquor seem to be blown from the filter vat to waste. Material removed by the screen is flushed to waste by water showers, wet room pit water being used. It was observed that one screen was discharging much more highly colored wastes than the other, evidently one screen was in need of repair.

Black Liquor Evaporator Condensate

The characteristics of this waste were necessarily determined by difference in characteristics of the water entering and leaving the condenser since the water entering already contained pollutants. Vapor from the last effect of the evaporators enters the barometric condenser and after condensing joins the condenser water. Condensate from all but the last effect is pumped to the condenser discharge. Since this waste is mixed with condenser water, it actually was not a separate waste but is considered as such here. With this

type of condenser, mixing of vapor from the last effect, and condenser water, will occur. This waste amounted to an average of 1.23 mgd, and contained 494 ppm B.O.D. This represents over 20 per cent of the B.O.D. load of pulp manufacturing wastes. Since the total solids content was considerably less than B.O.D., it may be concluded that some of the material was volatilized during the evaporation process of the total solids determination.

Recovery Room Waste

This waste consists in the main of condensate overflow from the forced draft air heaters in the recovery furnace cooling water from the furnace spouts, and blow down from the water cooled furnace walls. It contains very little pollutional material.

Green Liquor Dregs

This waste, which is composed of insoluble matter present in green liquor, is more than 60% total solids most of which are inorganic chemical compounds.

Lime Kiln Stack Gas Wash Excess

This waste contains essentially fine particles of calcium carbonate in suspension. Its B.O.D. load is slight.

27. Paper Manufacturing Wastes

Total Paper Manufacturing Process Wastes

Combined wastes from all seven machines amounted to 19.0 mgd and contained 142 ppm B.O.D. Considering all volatile suspended solids as pulp fiber, losses amounted to 3.3 per cent of paper product. B.O.D. loads per ton of pulp varied greatly among machines. The characteristics of wastes of individual paper machines are discussed in subsequent paragraphs.

TABLE 2 - AVERAGE OF DETERMINATIONS WASTES OF PAPER MANUFACTURE

Machine No.	Machine Production During Survey Tons	Type of Machine	Product	Flow mgd	BOD 5-day ppm	TOTAL SOLIDS Total ppm	TOTAL SOLIDS Volatile ppm	TOTAL SOLIDS Fixed ppm	SUSPENDED SOLIDS Total ppm	SUSPENDED SOLIDS Volatile ppm	SUSPENDED SOLIDS Fixed ppm	pH Range	Sulfides ppm	Color ppm
1	125	Cylinder	Fill Grades of Liner Board	2.10	127	644	423	221	456	412	44	4.9-6.7		
2	90	Cylinder	Fill Grades of Liner Board and Chipboard	2.35	84	438	206	232	192	174	18	5.5-6.5		
3	42	Cylinder	Solid kraft test liner board	Not measured nor sampled.										
4	126	Four-drinier	Corrugating Board	3.62	418	1455	1106	349	609	609	0	9.1-9.6	<0.1	2940
5	72	Four-drinier	Bag and wrap, lightweight	1.44	62	482	299	183	311	294	17	6.3-6.7		
6	90	Four drinier	Bag and wrap, heavy & industrial	1.94	55	321	128	193	128	116	11	6.5-6.8		
7	362	Four-drinier	Bag and Four-drinier liner board	Not measured nor sampled.										
Total Paper Manufacturing Process Wastes (Wastes from all seven machines)				19.0	142				361	329	32	6.9-8.5	<0.1	

TABLE 3
PAPER MACHINE WASTES
VOLUME - BOD - FIBER LOSS

Date	Flow mgd	Flow Gallons Per Ton of Product	BOD 5-day 20° ppm	BOD Pounds Per Ton of Product	Fiber Loss Pounds (Oven Dry) Per 1000 Gallons Waste	Fiber Loss % of Product
Machine No. 1 (60% sulfate pulp and 40% waste paper pulp)						
Nov. 13	2.36	19,000	177	28	3.0	3.1
Nov. 14	2.04	16,100	57	8	2.1	1.7
Nov. 15	2.32	17,800	154	23	6.1	5.8
Nov. 16	Down			-		
Nov. 17	1.69	14,200	122	14	2.6	1.9
Average	2.10	16,800	127	18	3.4	3.1
Machine No. 2 (55% sulfate pulp and 45% waste paper pulp)						
Nov. 13	2.47	34,300	124	35	1.9	3.4
Nov. 14	2.37	26,100	51	11	1.4	1.9
Nov. 15	2.37	25,000	56	12	1.1	1.5
Nov. 16	2.06	21,500	103	18	1.5	1.7
Nov. 17	2.49	25,400	85	18	1.4	1.8
Average	2.35	26,500	84	19	1.4	2.0
Machine No. 4 (50% Semichemical Pulp and 50% Sulfate Knot Pulp)						
Nov. 13	3.56	29,400	403	99		
Nov. 14	3.68	30,900	374	96	4.7	7.7
Nov. 15	3.65	27,400	427	97	4.6	6.6
Nov. 16	3.61	27,100	466	105	6.0	8.6
Nov. 17	Down during sampling period					
Average	3.62	28,700	418	100	5.1	7.7
Machine No. 5 (All kraft)						
Nov. 13	1.51	19,400	182[1]	29[1]	2.8	2.5
Nov. 14	1.44[1]		51[1]			
Nov. 15	1.23	16,000	66	8.8	1.34	1.6
Nov. 16	2.65[1]	39,000	199[1]	65[1]	4.5	9.3
Nov. 17	1.57	24,200	57	12	3.0	3.9
Average	1.44	19,900	62	10.4	2.4	2.6

1. Not considered in average for reasons that machine was down over part of sampling period, colored paper run, or apparently out of normal range.

TABLE 3 (Cont'd)
PAPER MACHINE WASTES
VOLUME - BOD - FIBER LOSS

Machine No. 6 (All kraft)
(Results computed from two portions of total wastes analyzed separately)

Date	Flow		BOD		Fiber Loss	
	mgd	Gallons Per Ton of Product	5-Day 20° ppm	Pounds Per Ton of Product	Pounds (Oven Dry) Per 1000 Gallons Waste	% of Product
Nov. 13	1.85	18,500	60	9.2	0.5	0.5
Nov. 14	1.48	17,600	45	6.6	0.9	0.9
Nov. 15	1.92	23,200	62	12	1.1	1.3
Nov. 16	2.36	30,700	57	15	1.0	1.6
Nov. 17	2.10	20,600	54	9.3	1.2	1.3
Average	1.94	22,100	55	10	1.0	1.1
		Total Paper Machine Wastes (Wastes from all Seven Machines)				
Nov. 13	18.7	21,200	160	28	2.5	2.8
Nov. 14	19.5	19,200	127	20	2.5	2.8
Nov. 15	19.0	19,100	119	19	2.5	2.5
Nov. 16	19.1	24,400	171	35	3.1	3.9
Nov. 17	18.8	30,800	132	34	3.1	5.1
Average	19.0	22,900	142	27	2.7	3.3

Cylinder Machines

Machines 1 and 2

Wastes from cylinder machines consists of water which drains through the cylinder mold in excess of that which is recirculated, and water removed from the pulp mat and felts by the extractor and press rolls. Material rejected on the flat screens is also flushed to the sewers. This water originates in the cylinder showers. In some machines, a felt shower is employed also. Vacuum pumps are sealed with the water withdrawn from the mat.

Variations found in this survey in the character of the waste are extreme, even when considering the wastes from a particular cylinder machine. Samples of total wastes from cylinder machines composited over 8 to 12 hours contained from 51 to 177 ppm B.O.D. Suspended solids ranged, with the exception of one high value, from 150 to 410 ppm, of which about 85 were volatile. One composite sample from Machine 1 had 782 ppm suspended solids. Considering volatile suspended solids as fiber, fiber losses of Machine 1 averaged 3.1% of product, while fiber losses of Machine 2 were 2.0%.

The flow measurements showed much greater amounts of water used per ton of paper produced by Machine 2 than by Machine 1. Machine 2 used about 26,000 gallons per ton of product, while Machine 1 used only about 17,000. The wastes of Machine 2 are appreciably less in strength. The B.O.D. pollutional load per ton of product of the two machines are comparable, averaging 18 and 19 pounds, respectively.

Fourdrinier Machines

Machine 4

Machine 4, which is used for making corrugating board, produces wastes exceptionally high in B.O.D., averaging 418 ppm. This is due to the

fact that semi-chemical pulp is not washed in the same manner as sulfate pulp. It may be considered that some of this waste is actually pulp wash water. Wastes per ton of product are in the order of 29,000 gallons.

The wastes of this machine were the only highly colored paper machine wastes with the exception of color runs on other machines. The other paper wastes have a murky gray appearance in deep flow, while wastes from machine 4 are a dark brown color resembling dilute black liquor. Total and suspended solids were both high. The waste contained an average of 100 pounds of B.O.D. per ton of product. Fiber losses averaged 7.7 per cent of paper produced.

Machine 5 and 6

Attention is called to the interconnections in the waste water systems of machine 5 and 6. It is possible that as much as 25% of the waste loads of these two machines was passing to the wet room pit via the thickener, and therefore would not be included in the results tabulated. With the exception of one day when the wastes from machine 5 were extremely high in B.O.D., the wastes from the two machines had fairly comparable pollutional loads and flow per ton of product. Disregarding results on the one sample, the B.O.D. of the waste was in the order of 60 ppm and the flow amounted to about 22,000 gallons per ton of paper produced. The pollution load was about 10 pounds of B.O.D. per ton of paper produced. Contrary to B.O.D. results, volatile suspended solids, which may be considered as fiber loss, was much greater for machine 5 than for machine 6. Considering all volatile suspended solids as pulp, the loss in fiber for machine 5 was 2.6 per cent of paper produced but for machine 6, only 1.1 per cent. Couch and

wire pit water going to waste from both of these machines is passed through rotary cylindrical screen filters referred to as savealls. It was possible, in the case of machine 6, to sample and measure the saveall filtrate receiving tank overflow separate from the other wastes. The saveall waste was quite similar in character to the other wastes of the machine. Saveall filtrate constituted only about one third of the total volume of wastes.

28. Total Plant Wastes

The plant wastes combine and leave the mill area in two sewers, here termed the East and West Sewer, figure 10. One waste, lime kiln stack gas wash excess, enters the East Sewer below the sampling and measuring point on that sewer. Averages of results obtained for each of these sewers is presented in table 4.

A balance between a summation of total paper machine wastes plus all component wastes of pulp manufacture, and the outfall sewers revealed considerable discrepancy, the sum of the components being lower than that of the outfall sewers. A slight discrepancy would be expected since certain minor wastes were not measured or sampled in any of the components, namely, domestic sewage, surface drainage, boiler blowdown, and water supply screen backwash. However, it is not anticipated that these minor wastes would anywhere near account for this discrepancy. Evidently, errors inherent in sampling, measuring, and analyses all happened to occur in an accumulative manner in this limited number of observations.

Even though this discrepancy is unaccounted for, the results on the outfall sewers are considered acceptable in computing wastes loads per ton of product. Data on the component wastes serve their purpose of indicating the relative order of the various process operations in contributing to factory wastes.

TABLE 4 - TOTAL PLANT WASTES

Waste	Flow mgd	BOD 5-Day 20° C. ppm	BOD 5-Day 20° C. lbs/day	Total Solids Total ppm	Total Solids Volatile ppm	Total Solids Fixed ppm	Suspended Solids Total ppm	Suspended Solids Volatile ppm	Suspended Solids Fixed ppm	pH Range	Alkalinity M.O.	Color ppm
West Sewer	16.8	297	41,500	2234	1104	1129	1475	754	721	8.5-9.4	1421	1180
East Sewer	13.0	221	23,900	814	512	303	467	423	44	6.5-7.3	53	580
Lime Kiln Stack Gas Wash	0.648	21	113	2636						9.9-11.8		
Total Above	30.4	269	65,500									

29. Special Characteristics

Color

Color is of particular significance in pulp and paper mill wastes in that the wastes are highly colored and the color is unusually persistent. It has been observed that after much organic matter in the wastes has been destroyed by bacterial action, the color is still present in concentrations equal to or greater than initially. This has been explained as being due to partially oxidized color constituents yielding higher color intensities than the original compounds.

The wastes in the East and West Sewers averaged 580 and 1180 ppm color respectively. A combination of these sewers would have about 920 ppm color. This color comes from a relatively few constituents. The wastes from paper machine 4, which handles the semi-chemical pulp, contains a very high color load, averaging 2940 ppm. This high color is due apparently to the fact that this pulp is not washed to the extent that sulfate pulp is washed. Wastes from this machine carry 39% of the total color load. A few wastes of pulp manufacture, namely, black liquor weir wastes, brown stock washer waste, wet room pit water, and black liquor filter backwash, contain probably about 50% of the remaining color load. These wastes amount to about 4 mgd.

During manufacture of colored paper, the loss of dyes to the wastes will increase the color concentrations beyond the results reported here.

Sulfides

Sulfides are oxidized or escape from exposed surfaces very rapidly.

For instance, water entering the log flume contains about 16 ppm sulfides but, after passing through the flume, a matter of less than 2 minutes, the sulfide content was reduced to about 5 ppm. Considering the sulfide content at the point of sampling of component wastes, the results show that more than 90% of the sulfides contained in the liquid wastes came from black liquor evaporation, and were contained in the barometric condenser water and black liquor evaporator condensate mixture.

No determinations were made to determine the content of mercaptans. However, lack of typical mercaptan odor to any appreciable extent indicated that mercaptan concentrations were negligible.

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APPENDIX

INDIVIDUAL DETERMINATIONS
PULP MANUFACTURING WASTES

LOG FLUME WATER *
(Pollution Attributable to Log Fluming Operation)

Date 1950	Flow MGD	BOD ppm	Oxygen Consumed ppm	Total Solids			Suspended Solids			pH	Sulfides ppm	Alkalinity		Color ppm
				Total ppm	Volatile ppm	Fixed ppm	Total ppm	Volatile ppm	Fixed ppm			P ppm	MO ppm	
Oct. 30	10.70	12	155	126	120	6	-	-	-	7.5-7.2	-	-	22	-100
Oct. 31	10.22	-10	214	342	196	146	88	56	32	7.9-7.5	-10	-	18	0
Nov. 1	10.59	18	84	-24	-18	-6	-66	-64	-2	8.3-8.3	-5	-	-3	-100
Nov. 2	9.68	-33	32	58	126	-68	364	330	34	8.4-8.4	-10	-4	1	0
Nov. 3	10.15	30	77	122	64	58	-129	-128	-1	7.9-7.5	-14	-	-3	0
Average	10.27	3	112	125	98	27	51	39	13	7.5-8.4	-10	-1	7	-40
BLACK LIQUOR WEIR														
Oct. 30	0.116	1930	5697	5556	3362	2194	-	-	-	10.5	-	550	2082	3556
Oct. 31	0.146	372	1278	1604	932	672	56	52	4	10.2	1.5	138	638	1604
Nov. 1	0.076	310	1484	1940	1220	720	156	156	0	10.3	2.5	178	653	1940
Nov. 2	0.080	144	934	1250	702	548	64	64	0	10.2	1.5	117	491	1250
Nov. 3	0.093	222	949	1186	656	530	92	91	1	10.4	3.5	125	470	1186
Average	0.102	596	2068	2307	1376	933	92	91	1	10.2-10.5	1.8	221	867	1907
DIGESTER ROOM NO.2														
Oct. 30	0.635	584	-	478	322	156	-	-	-	9.4	-	-	-	650
Oct. 31	0.635	414	-	486	304	182	-	-	-	9.4	3.0	-	-	-
Nov. 1	0.635	409	-	704	474	230	-	-	-	9.8	2.5	-	-	-
Nov. 2	0.635	364	-	538	328	210	-	-	-	9.6	6.0	117	374	-
Nov. 3	0.635	228	-	420	242	178	-	-	-	9.5	4.0	-	-	-
Average	0.635	400	-	525	334	191	-	-	-	9.4-9.8	3.9	-	-	-

* The log flume water supply was water which already contained pollutional matter from previous uses. The data tabulated below is the difference in the characteristics of the water before and after use for log fluming. Reference is made to page 64 which lists the original data. Concentrations attributable to log fluming are obtained by subtracting those of the log flume water supply, which is "Condenser Feed Water, plus Evaporator Water, plus Evaporator Condensate," from those of "Log Flume Water Discharge."

INDIVIDUAL DETERMINATIONS
PULP MANUFACTURING WASTES Cont'd - 2

TURPENTINE SEPARATOR

Date 1950	Flow MGD	BOD ppm	Oxygen Consumed ppm	Total Solids Total ppm	Total Solids Volatile ppm	Total Solids Fixed ppm	Suspended Solids Total ppm	Suspended Solids Volatile ppm	Suspended Solids Fixed ppm	pH	Sulfides ppm	Alkalinity P ppm	Alkalinity MO ppm	Color ppm
Oct. 30	0.019	8660	9584	84	54	30	-	-	-	9.4	-	-	-	-
Oct. 31	0.019	8160	10383	124	84	40	-	-	-	9.4	45	-	-	-
Nov. 1	0.022	7660	10867	184	106	78	-	-	-	9.4	30	-	-	-
Nov. 2	0.027	5960	9785	156	108	48	-	-	-	9.4	40	-	-	-
Nov. 3	0.024	8320	10655	110	77	33	-	-	-	9.3	40	-	-	-
Average	0.022	7750	10255	132	86	46	-	-	-	9.3-9.4	39	-	-	-

BROWN STOCK WASHER WASTE

Oct. 30	0.48	1365	-	5238	2958	2280	1196	616	580	10.4	-	-	-	8000
Oct. 31	0.50	1013	-	4788	2860	1928	-	-	-	10.5	<0.1	-	-	-
Nov. 1	0.46	1130	-	5612	3382	2230	-	-	-	10.3	<0.1	-	-	-
Nov. 2	0.56	200	-	1544	1004	540	-	-	-	9.7	<0.1	-	-	-
Nov. 3	0.50	1228	-	-	-	-	-	-	-	10.6	<0.1	-	-	-
Average	0.50	987	-	4295	2551	1744	-	-	-	9.7-10.6	<0.1	-	-	-

WET ROOM PIT WATER

Oct. 30	2.97	320	-	1346	832	514	144	136	8	10.4	-	116	534	2250
Oct. 31	2.87	239	-	1244	818	426	128	120	8	10.2	0.2	88	423	-
Nov. 1	2.38	529	-	2240	1586	654	352	336	16	10.5	0.2	177	697	-
Nov. 2	2.68	274	-	1752	1000	752	108	108	0	9.7	<0.1	91	536	-
Nov. 3	3.71	329	-	1446	884	562	244	242	2	10.5	<0.1	131	471	-
Average	2.92	338	-	1605	1024	581	195	188	7	9.7-10.5	0.1	120	532	-

INDIVIDUAL DETERMINATIONS
PULP MANUFACTURING WASTES Cont'd - 3

BLACK LIQUOR FILTER BACK WASH

Date 1950	Flow MGD	BOD ppm	Oxygen Consumed ppm	Total Solids			Suspended Solids			pH	Sulfides ppm	Alkalinity		Color ppm
				Total ppm	Volatile ppm	Fixed ppm	Total ppm	Volatile ppm	Fixed ppm			P ppm	MO ppm	
Nov. 13	0.06	1670	-	6872	3956	2916	-	-	-	10.6	6.0	-	-	13,000
Nov. 14	0.06	810	-	4154	2214	1940	-	-	-	10.5	5.0	-	-	7,000
Nov. 15	0.06	1030	-	4752	2782	1970	-	-	-	10.5	7.0	-	-	8,000
Nov. 16	0.06	4530	-	19198	11850	7348	-	-	-	10.9	7.0	-	-	45,000
Nov. 17	0.059	6450	-	5504	3326	2178	-	-	-	10.6	5.0	-	-	13,000
Average	0.06	2900	-	8096	4826	3270	-	-	-	10.5-10.9	6.0	-	-	17,000

BLACK LIQUOR EVAPORATOR CONDENSATE
(Characteristics by difference in water entering and leaving the condenser)

Oct. 30	1.25	500		Neg.	30						-			
Oct. 31	1.265	770		120	130						81			
Nov. 1	1.23	110		730	670						86			
Nov. 2	1.20	420		Neg.	Neg.						161			
Nov. 3	1.22	670		500	Neg.						165			
Average	1.23	494		270	166						123			

RECOVERY ROOM WASTE

Oct. 30	0.68	6	-	532	180	352	-	-	-	9.6	-	-	-	110
Oct. 31	0.60	32	-	734	338	396	-	-	-	9.4	<0.1	-	-	-
Nov. 1	0.51	17	-	620	252	368	-	-	-	9.5	<0.1	-	-	-
Nov. 2	0.48	4	-	364	120	244	-	-	-	9.1	<0.1	-	-	-
Nov. 3	0.48	2	-	274	66	208	-	-	-	9.1	<0.1	-	-	-
Average	0.55	12	-	505	191	314	-	-	-	9.1-9.6	<0.1	-	-	-

INDIVIDUAL DETERMINATIONS
PULP MANUFACTURING WASTES Cont'd - 4

GREEN LIQUOR DREGS

Date 1950	Flow MGD	BOD ppm	Oxygen Consumed ppm	Total Solids			Suspended Solids			pH	Sulfides ppm	Alkalinity		Color ppm
				Total ppm	Volatile ppm	Fixed ppm	Total ppm	Volatile ppm	Fixed ppm			P ppm	MO ppm	
Nov.14	0.0085	1260	-	668400	12560	655840	665760	-	-	>12.2	-	-	-	-
Nov.15	0.0085	1390	-	660480	16000	644480	643520	15680	627846	>12.2	1250	-	-	-
Nov.15	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nov.16	0.0085	1130	-	567680	16320	551360	504640	12800	491840	>12.2	600	-	-	-
Nov.17	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Average	0.0085	1260	-	632190	14960	617230	604640	14240	559843	>12.2	925	-	-	-

LIME KILN STACK GAS WASH EXCESS

Nov.13	0.582	4.9	-	1052	-	-	-	-	-	9.9	2.5	-	-	-
Nov.14	0.635	9.8	-	1818	-	-	-	-	-	10.7	1.5	-	-	-
Nov.15	0.655	5.8	-	1628	-	-	-	-	-	10.5	7.0	-	-	-
Nov.16	0.671	54	-	4172	-	-	-	-	-	11.8	8.0	-	-	-
Nov.17	0.697	28	-	4508	-	-	-	-	-	11.0	10.0	-	-	-
Average	0.648	21	-	2636	-	-	-	-	-	9.9-11.8	5.8	-	-	-

MILL EFFLUENT - WEST SEWER

Oct.30	16.8	269	860	2130	999	1138	1408	700	708	8.8	-	0	1509	1000
Oct.31	16.6	275	850	1868	920	948	1196	616	580	9.3	6.0	0	1147	1000
Nov. 1	16.9	339	1023	2170	1150	1020	1212	668	544	9.1	5.0	77	1184	1300
Nov. 2	16.5	271	957	2236	1104	1132	1416	692	724	9.4	6.0	21	1351	1400
Nov. 3	17.0	330	1029	2766	1356	1410	2144	1096	1048	8.5	4.0	59	1914	1200
Average	16.8	297	938	2234	1104	1129	1475	754	721	8.5-9.4	4.2	31	1421	1180

INDIVIDUAL DETERMINATIONS
PULP MANUFACTURING WASTES Cont'd - 5

CONDENSER WATER *

Date 1950	Flow MGD	BOD ppm	Oxygen Consumed ppm	Total Solids			Suspended Solids			pH	Sulfides ppm	Alkalinity		Color ppm
				Total ppm	Volatile ppm	Fixed ppm	Total ppm	Volatile ppm	Fixed ppm			P ppm	MO ppm	
Oct. 30	9.45	260	-	1450	520	930	-	-	-	9.1	-	-	-	1100
Oct. 31	8.96	208	-	926	616	310	-	-	-	9.1	<0.1	-	-	-
Nov. 1	9.36	235	-	906	554	352	-	-	-	9.4	<0.1	-	-	-
Nov. 2	8.48	205	-	1162	848	314	-	-	-	9.6	-	-	-	-
Nov. 3	8.92	191	-	762	468	294	-	-	-	9.1	<0.1	-	-	-
Average	9.03	220	-	922	603	319	-	-	-	9.1-9.6	<0.1	-	-	-

CONDENSER FEED WATER PLUS EVAPORATOR CONDENSATE *

Oct. 30	10.70	288	721	760	464	296	-	-	-	7.5	-	0	134	800
Oct. 31	10.22	278	843	826	522	304	324	324	0	7.9	15	0	120	800
Nov. 1	10.59	221	785	888	568	320	308	302	6	8.3	10	0	96	900
Nov. 2	9.68	231	807	806	506	300	296	294	2	8.4	20	8	124	1000
Nov. 3	10.14	249	785	730	452	278	441	438	3	7.9	20	1	75	900
Average	10.27	253	788	802	502	300	342	339	3	7.5-8.4	16	2	110	880

LOG FLUME WATER DISCHARGE *

Oct. 30	10.70	300	876	886	584	302	278	278	0	7.2	-	0	156	700
Oct. 31	10.22	268	1057	1110	718	397	412	380	32	7.5	5.0	0	138	800
Nov. 1	10.59	239	869	864	550	314	242	238	4	8.3	5.0	0	93	800
Nov. 2	9.68	198	840	864	632	232	660	624	36	8.4	10.0	4	121	1000
Nov. 3	10.14	279	863	852	516	336	312	310	2	7.5	6.0	0	72	900
Average	10.27	257	901	916	600	316	381	366	15	7.2-8.4	5.2	1	116	840

* Data tabulated on this page was gathered to obtain information on black liquor evaporator condensate and pollution attributable to log flowing. Condenser feed and log flume water supply were waste waters and already contained pollutional matter from previous uses, this necessitating obtaining data by difference. Reference is made to the text and to figure 10 for complete explanation.

INDIVIDUAL DETERMINATIONS
PAPER MANUFACTURING WASTES Cont'd - 6

MACHINE NO. 1

Date 1950	Flow MGD	BOD ppm	Oxygen Consumed ppm	Total Solids			Suspended Solids			pH	Sulfides ppm	Alkalinity P ppm	Alkalinity MO ppm	Color ppm
				Total ppm	Volatile ppm	Fixed ppm	Total ppm	Volatile ppm	Fixed ppm					
Nov. 13	2.36	177	-	600	368	232	412	364	48	6.3	-	-	-	-
Nov. 14	2.04	57	-	428	250	178	304	246	58	6.5	-	-	-	-
Nov. 15	2.32	154	-	1074	758	316	782	730	52	4.9	-	-	-	-
Nov. 16	Down	-	-	-	-	-	-	-	-	-	-	-	-	-
Nov. 17	1.69	122	-	474	316	158	328	310	18	6.7	-	-	-	-
Average	2.10	127	-	644	423	221	456	412	44	4-9-6.7	-	-	-	-
MACHINE NO. 2														
Nov. 13	2.47	124	-	513	279	234	268	228	40	5.9	-	-	-	-
Nov. 14	2.37	51	250	474	220	254	178	162	16	5.5	-	-	-	-
Nov. 15	2.37	56	227	430	180	250	152	136	16	6.1	-	-	-	-
Nov. 16	2.06	103	-	362	186	176	196	180	16	6.5	-	-	-	-
Nov. 17	2.49	85	221	410	166	244	164	162	2	6.5	-	-	-	-
Average	2.35	84	233	458	206	232	192	174	18	5.5-6.5	-	-	-	-
MACHINE NO. 4														
Nov. 13	3.56	403	1334	1208	950	258	-	-	-	9.1	<0.1	-	196	1750
Nov. 14	3.68	374	1619	1364	1042	322	564	564	0	9.1	<0.1	-	183	2250
Nov. 15	3.65	427	1767	1582	1150	432	548	548	0	9.6	<0.1	-	259	3250
Nov. 16	3.61	466	1854	1668	1284	384	716	716	0	9.3	<0.1	20	247	4500
Nov. 17	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Average	3.62	418	1643	1455	1106	349	609	609	0	9.1-9.6	<0.1	-	221	2940

INDIVIDUAL DETERMINATIONS
PAPER MANUFACTURING WASTES Cont'd - 7

MACHINE NO. 5

Date 1950	Flow MGD	BOD ppm	Oxygen Consumed ppm	Total Solids Total ppm	Total Solids Volatile ppm	Total Solids Fixed ppm	Suspended Solids Total ppm	Suspended Solids Volatile ppm	Suspended Solids Fixed ppm	pH	Sulfides ppm	Alkalinity P ppm	Alkalinity MO ppm	Color ppm
Nov. 13	1.51	182*	-	537	345	192	380	334	46	6.5	-	-	26	-
Nov. 14	1.44*	51*	250*	392*	196*	196*	184*	176*	8*	6.5*	-	-	24*	-
Nov. 15	1.23	66	222	370	186	184	192	186	6	6.3	-	-	21	-
Nov. 16	2.63*	199*	-	746*	554*	192*	538*	536*	2*	6.7*	-	-	26*	-
Nov. 17	1.57	57	463	540	366	174	362	362	0	6.7	-	-	30	-
Average	1.44	62	344	482	299	183	311	294	17	6.3-6.7	-	-	26	-

Note: *Not considered in average for reasons that machine was down over part of sampling period, colored paper run, or out of apparently normal range.

MACHINE NO. 6
(Waste waters going through saveall not included)

Nov. 13	1.33	42	-	280	84	196	46	32	14	6.6	-	-	-	-
Nov. 14	1.25	45	-	310	148	162	114	112	2	6.7	-	-	-	-
Nov. 15	1.04	62	-	304	144	160	160	142	18	6.8	-	-	-	-
Nov. 16	1.57	55	-	290	120	170	124	118	6	6.7	-	-	-	-
Nov. 17	1.43	54	-	380	186	194	174	174	0	6.7	-	-	-	-
Average	1.32	52	-	313	136	176	124	116	8	6.6-6.8	-	-	-	-

MACHINE NO.6
(Saveall Waste)

Nov. 13	0.524	105	-	410	164	246	156	136	20	6.5	-	-	-	-
Nov. 14	0.226	45	103	270	86	184	138	-	-	6.5	-	-	-	-
Nov. 15	0.875	62	158	344	138	206	146	126	20	6.7	-	-	-	-
Nov. 16	0.786	60	-	314	120	194	138	120	18	6.5	-	-	-	-
Nov. 17	0.671	53	118	312	90	222	86	86	0	6.7	-	-	-	-
Average	0.616	65	126	330	120	210	133	117	19	6.5-6.7	-	-	-	-

INDIVIDUAL DETERMINATIONS
PAPER MANUFACTURING WASTES Cont'd - 8

Date 1950	Flow MGD	BOD ppm	Oxygen Consumed ppm	Total Solids			Suspended Solids			pH	Sulfides ppm	Alkalinity		Color ppm
				Total ppm	Volatile ppm	Fixed ppm	Total ppm	Volatile ppm	Fixed ppm			P ppm	MO ppm	
TOTAL PAPER MACHINE WASTES (Includes Wastes from all seven Paper Machines)														
Nov. 13	18.7	160	-	-	-	-	352	300	52	6.9	<0.1	-	-	-
Nov. 14	19.5	127	-	-	-	-	356	300	56	6.9	<0.1	-	-	-
Nov. 15	19.0	119	-	-	-	-	304	300	4	7.7	<0.1	-	-	-
Nov. 16	19.1	171	-	-	-	-	392	368	24	8.5	0.1	-	-	-
Nov. 17	18.8	132	-	-	-	-	400	376	24	7.3	<0.1	-	-	-
Average	19.0	142	-	-	-	-	361	329	32	6.9-8.5	<0.1	-	-	-
MILL EFFLUENT - EAST SEWER														
Nov. 13	13.2	369	1124	1004	816	188	704	580	124	6.7	-	-	52	550
Nov. 14	13.4	235	817	870	554	316	620	552	68	6.9	-	-	57.6	600
Nov. 15	14.1	195	798	894	520	374	396	392	4	6.7	-	-	53.2	700
Nov. 16	11.4	195	735	756	436	320	400	384	16	6.5	-	-	44.8	700
Nov. 17	13.0	110	367	548	232	316	216	208	8	7.3	-	-	59.2	350
Average	13.0	221	768	814	512	303	467	423	44	6.5-7.3	-	-	53.4	580